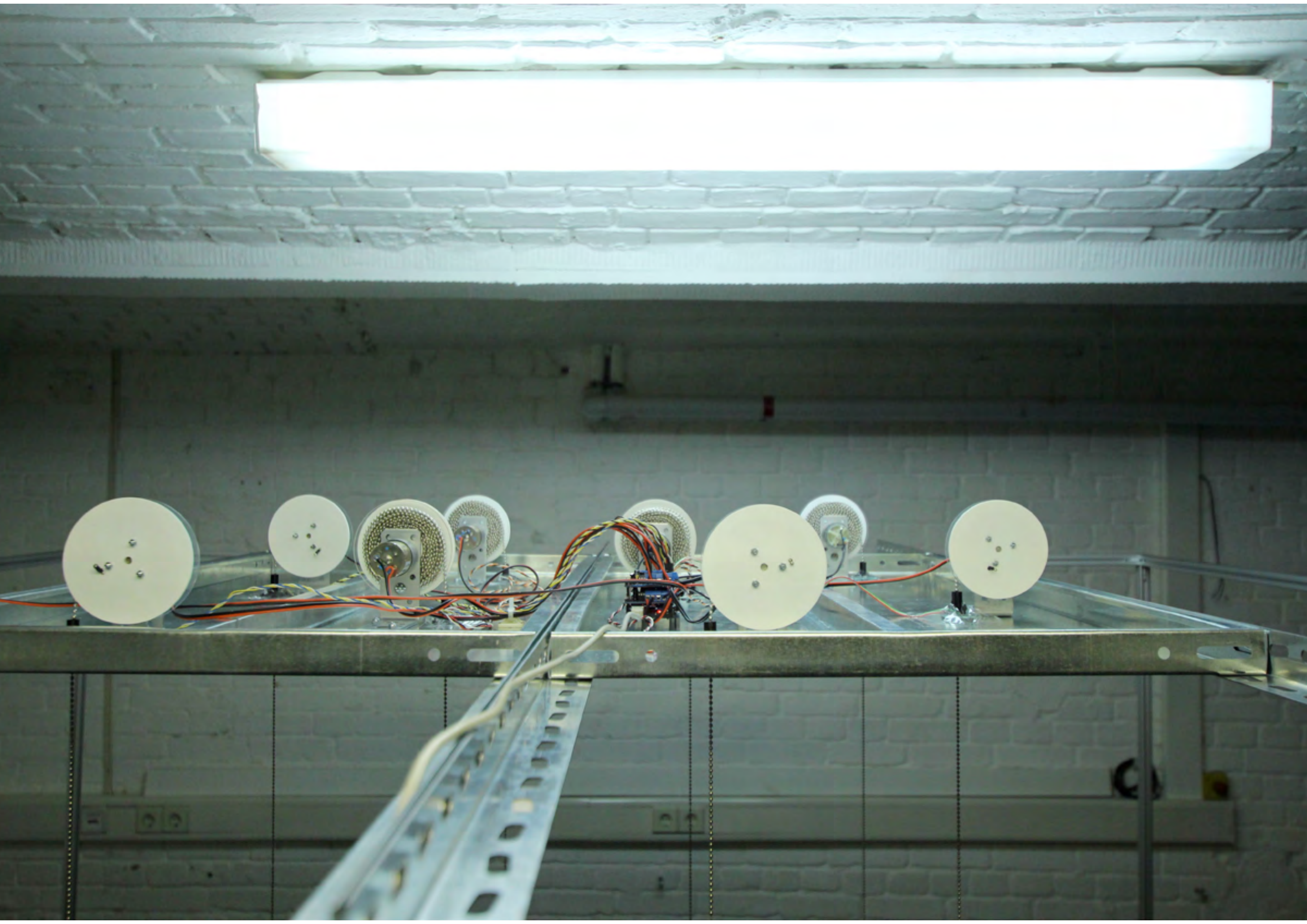
An Interdisciplinary Laboratory   The Excellence Cluster at the Humboldt-Universität zu Berlin

Image Knowledge Gestaltung

Newsletter

March 2016 #10



Editorial

In collaboration with the system developer Stefan Vollmar, the base project »Mobile Structures« has spent the last weeks developing the electromechanical system for its kinetic spatial installation and testing different prototypes. At the end of May, the team will launch series production of 96 panels with 384 motors, coils and ball chains for a walk-in spatial installation as part of the exhibition »+ultra.knowledge creates gestaltung« in the Martin-Gropius-Bau. The photograph of prototype 2 shows the construction, functionality and durability of the motors, coils, ball chains and base of the photoelectric sensor being tested. Photo: Benjamin Meurer | Image Knowledge Gestaltung 2016.

Dear Readers,

The *Brachiosaurus brancai*, an East African find from 1906, was used by the base project »Mobile Objects« as an object that paradigmatically illustrates that politics, science and scholarship, culture, society, technology, infrastructures and the economy are inextricably interlinked. Ina Heumann, Marco Tamborini and Mareike Vennen discussed negotiating, mobilising and transporting at a *LunchTalk* in the Interdisciplinary Laboratory. You can read their report from page 5.

Anne Dippel from the group »Experimental Systems« reports on the *LunchTalk* by the particle physicist Hans Drevermann from CERN and the workshop he led. You can read about how knowledge emerged from images and what role central perspective and human vision play in this process in her report on page 7.

The main items on the agenda at the Interdisciplinary Laboratory's fourth *Retreat* were the new prioritisation of its work and presenting the results of the projects that have completed their research. You can find a summary on pages 8–20.

The base project »Matter of Typography« held a workshop on the relationship between digital and analogue typography, which explored the influence exerted by support materials on characters. The materially, technically and aesthetically varied interrelationship between representational materials and the possibilities for creative expression were discussed with participants from various academic disciplines and fields of application. You can read about what they learnt about the economic and social dimensions of typesetting from page 22.

The announcement this February that gravitational waves had been experimentally validated has inspired Stefan Zieme to take a closer look at the general theory of relativity. Read more from page 27.

Enjoy reading *Newsletter#10*.

Best regards,

Claudia Lamas Cornejo
Head of Public Relations & Fundraising

The *LunchTalk* in the *Interdisciplinary Laboratory*

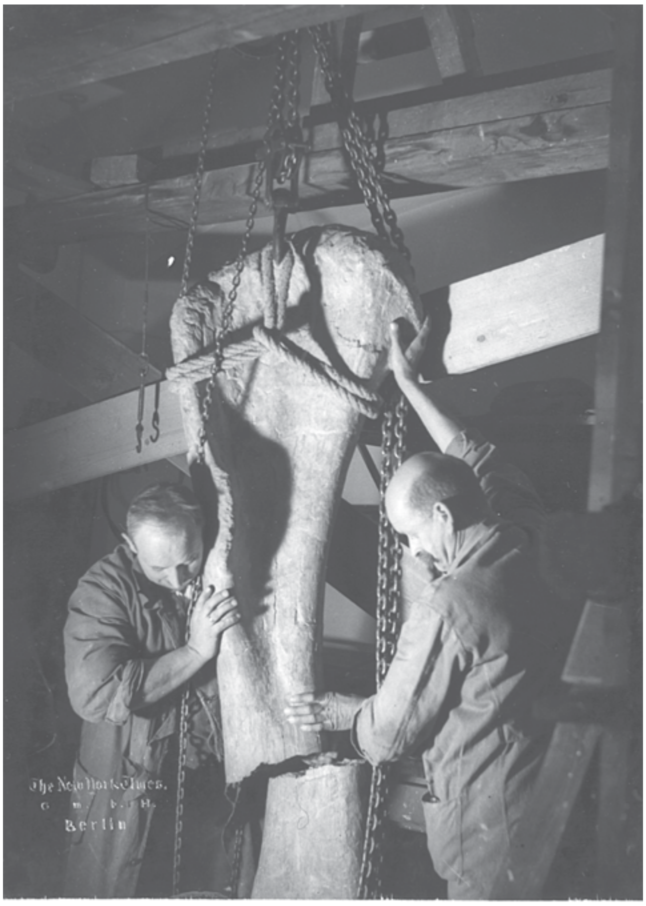
The *LunchTalk* in the *Interdisciplinary Laboratory* is held weekly from 12.30 to 2 p.m. on Tuesdays. External persons may attend on request. (Photo: Claudia Lamas Cornejo | BWG 2014)

The *LunchTalk* is a permanent fixture in the Excellence Cluster week at the *Interdisciplinary Laboratory*. On Tuesdays from 12.30 to 2 p.m., members of the Excellence Cluster or invited speakers give a talk on relevant topics. Excellence Cluster members then discuss the talk in order to identify points of reference, interfaces with or differences to their own work in the Cluster. The *LunchTalk* provides members with an opportunity to exchange ideas informally and discuss issues in their research in a protected internal space. Here they can float ideas, theses and findings that are not yet 100 per cent ready for publication and open them to debate amongst researchers in different disciplines. This is why, as a general rule, the *LunchTalk* is not open to non-members of the Cluster. If you are interested, please send an enquiry to bwg.publicrelations@hu-berlin.de. Suggestions for contributions by external speakers can also be sent to this address.

Claudia Lamas Cornejo
Head of Public Relations & Fundraising

LunchTalk reports January – March 2016

LunchTalk report *Negotiating, mobilising, transporting. On the history of the Berlin »Brachiosaurus brancai«*



Constructing the *Brachiosaurus brancai* in the loft of the Museum für Naturkunde Berlin (MfN, HBSB, Pal. Mus., B III/15).

Bamboo transportation box with baobab husks and cotton as packaging material for the bones. Photo © Hwa Ja Götz.

The history of the Berlin dinosaur skeleton *Brachiosaurus brancai* begins with a chance incident: in 1906, a German mining engineer stumbled across a bone that had been exposed by weathering in what was then German East Africa and now Tanzania. The expedition mounted to explore the find further was led by the Museum für Naturkunde Berlin. Between 1909 and 1913, palaeontologists and up to 800 African workers unearthed 250 tonnes of fossils, which were prepared in the following years and, in some cases, displayed in the museum's atrium. The »Dinosaurs in Berlin« project by the Federal Ministry of Education and Research (BMBF) examines this excavation and the finds from a multidisciplinary perspective and presented its work at a *LunchTalk*.

Negotiating

Marco Tamborini offered insights into his investigation of the importance of the finds for the history of science. He analysed the epistemic and social strategies deployed by the German palaeontologists in order to renegotiate a biological space for palaeontological natural history (1). German palaeontologists saw the East African expedition as an opportunity to establish their field of science as a first-class biological discipline – and not a geological one.

In 1984, the famous palaeontological objects from the Museum für Naturkunde Berlin were exhibited in Tokyo in the dome tent shown in this photograph (MfN, HBSB, B III/ 977; photo: ADN, Wittek, 1984).

Mobilising

Ina Heumann described how the *Brachiosaurus brancai* and additional key pieces from the museum's palaeontological collection were lent to Tokyo in 1984 (2). Reconstructing the political and economic calculations made in the GDR, the public debate and the interests within the museum clearly illustrated how complex the processes of mobilising museum objects are and how productive the previously neglected cultural history of the dinosaur in the GDR can be.

Transporting

Mareike Vennen examined the packaging and logistics history of the expedition. Taking the material culture of its transportation as her point of departure, her work has revealed, on the one hand, the practices and actors involved in the fossils' transformation into museum objects. On the other, she reconstructed the »supporting« role played by the packaging materials in the history of a transfer of knowledge and culture: which preservatives were imported and which were available locally? How were imported knowledge and means of transport combined with local knowledge and practices? Alongside the transport of objects, she was also interested in movements of images within the media history of the expedition: how and for what purpose were photographs and drawings produced, prepared and used?

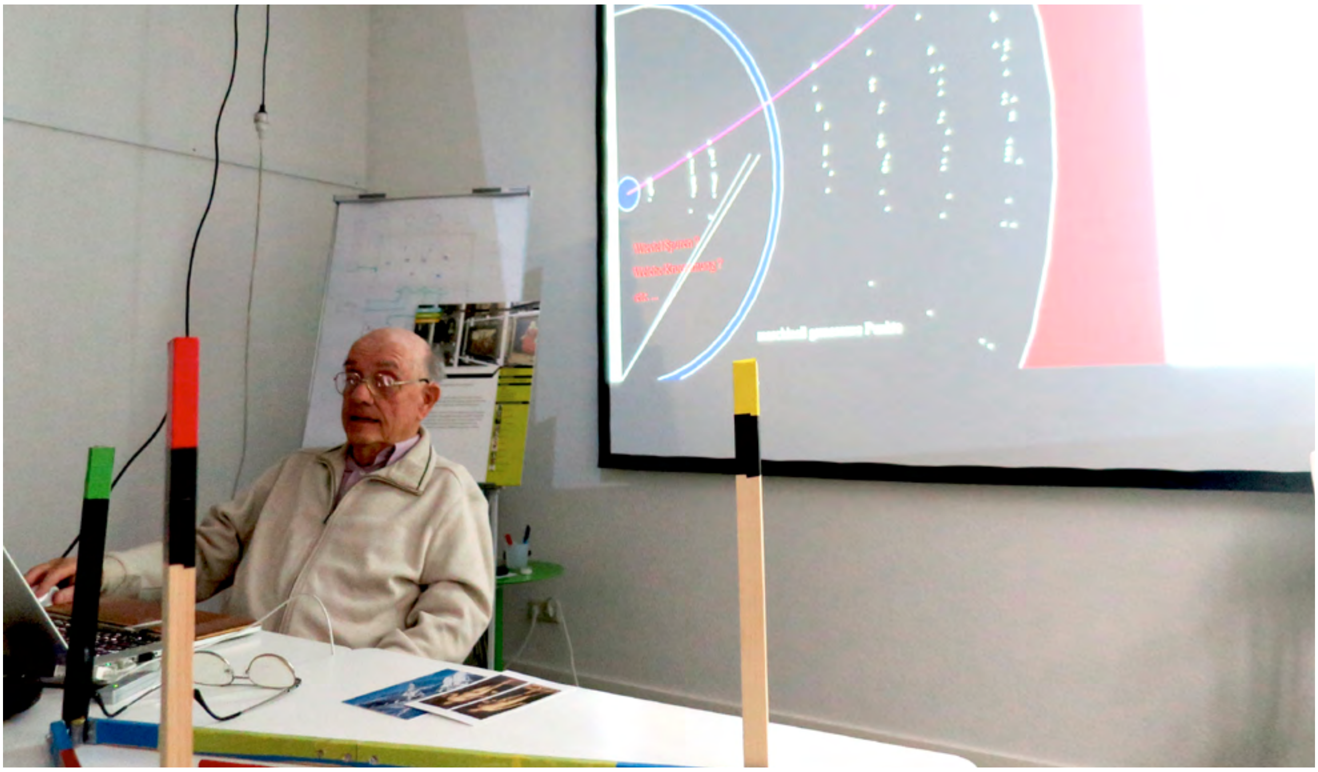
The *Brachiosaurus brancai* as a pars pro toto for the East African finds was revealed as an object that paradigmatically illustrates the inextricable interconnections between politics, science and scholarship, culture, society, technology, infrastructures and the economy. When the object was re-exhibited in 2007, the Berliner Kurier wrote: »Ha-ha, ours is the biggest. We easily beat the US-asaurus,« clearly demonstrating just how tightly bound to national economies these objects still are.

(1) On the features of palaeontological natural history, see Marco Tamborini, Paleontology and Darwin's Theory of Evolution. The Subversive Role of Statistics at the End of the 19th Century, in: Journal of the History of Biology 48 (2015), 575 - 612.

(2) Cf. Ina Heumann: Knochenbotschaft, in: Wissensdinge. Geschichten aus dem Naturkundemuseum, ed. by Anita Hermannstädter, Ina Heumann and Kerstin Pannhorst, Berlin 2014, p. 156–159.

Ina Heumann, Marco Tamborini, Mareike Vennen

LunchTalk and workshop report *Hans Drevermann (CERN)*



Hans Drevermann during his workshop »Can we paint what we see? Reflections on the psychophysics of perception«, which took place on 13 January 2016 in the Interdisciplinary Laboratory. Photo: Anne Dippel.

Hans Drevermann (CERN) was a Fellow in the Experimental Systems working group from 11 to 15 January 2016. As a particle physicist at CERN, he began by creating data from images in bubble chambers in the 1970s. With the digitalisation of detectors in the Large Electron-Positron Collider in the 1980s, his task was to generate images from data using the ALEPH detector. Improvements in data acquisition technology since the mid-1980s have led to the automation of the processes of making discoveries at CERN. The importance of images for discoveries in high-energy physics came to an end. During this time, Hans Drevermann created his first visualisation programme for the ALEPH detector: Dali. After the construction of the Large Hadron Collider, he was assigned a new task. He developed the »Event Display« for the ATLAS detector and the associated programme ATLANTIS, which is still used today by physicists at CERN as a technical control image.

Drevermann's images were discussed by Peter Galison in 2002 in »Iconoclash«, edited by Bruno Latour and Peter Weibel, and in other commentaries, and were exhibited at the Center for Art and Media (ZKM) in Karlsruhe.

In the Cluster, Hans Drevermann outlined how knowledge emerged from images, explored in the *LunchTalk* whether scientific images are of interest to non-scientists and took part in a workshop where he discussed fundamental assumptions and mathematical reflections on the central perspective and the human model of vision. These reflections are the result of his many years of work on and with images.

Anne Dippel
Experimental Systems & gamelab.berlin

Contributions & reports

Retreat 2016

Horst Bredekamp and Wolfgang Schäffner introduced the programme of the conference , which aimed to set out the current state of affairs in Cluster research and, building on this, to enable the Cluster to prepare its report to the expert commission in May 2016. The two Directors also emphasised that they hoped the *Retreat* would provide new stimulus for the prioritisation of the Cluster's work and its second phase, as well as helping prepare themes for an application for an extension. Photos: Claudia Lamas Cornejo | Image Knowledge Gestaltung 2016.

Project presentations at the Retreat 2016

Base project »Historical Structural Investigations in the Laboratory«

Structural research on biological materials was conducted at a very high level in the natural sciences between 1870 and 1941, and was then superseded by genetics and molecular biology. The results of this work have since disappeared from the typical scope of the laboratory, but they have made their way into design practice in architecture, urban development and engineering. It is in this context that cultural studies has begun in recent years to move beyond exclusively humanities-oriented structuralism and to develop a transdisciplinary history of structures. The project links these different perspectives and is developing a material-, structure- and function-specific explorer. The aim is for this explorer to serve as an interdisciplinary tool that enables technically interesting material structures to be identified in past research.

Base project »Architectures of Knowledge«

The project explores the relationship between space and collaborative research processes – how can space be defined in a comprehensive, integrative sense? How do physical, digital, social and cultural spaces constitute our actions, knowledge and communication? And what are the principles on which spaces of interdisciplinary research can be designed and modelled? These questions have been investigated since April 2015 in an unusual experimental setting: 40 researchers from a large number of disciplines collaborate in the Experimental Zone and are the subjects of an observational experiment. Different configurations of space are designed, tested and observed in the monthly experimental settings. This enables not only an exploration of space itself or forms of collaboration, but also an exploration of the possibilities for experimentalising space.

Base project »Experiment & Observation«

From the perspective of science studies, the project examines how knowledge operates in complex research collaborations, the extent to which such collaborations can be designed and the effect of design in interdisciplinary research projects. Its central focus is the issue of the structure and function of interdisciplinary collaborations. The project seeks to answer these questions in two working groups: *Experiment, Analyse and Design (EAG)*, which develops and tests analytical and design tools, and *Question, Observe and Describe (BBB)*, which bases its work on the process of empirical investigations. Their shared objective is to generate knowledge about interdisciplinary processes and structures and their visualisation. Here the Cluster acts as an object of observation and a space for experimentation. The project also studies the methodological link between experimentation and observation.

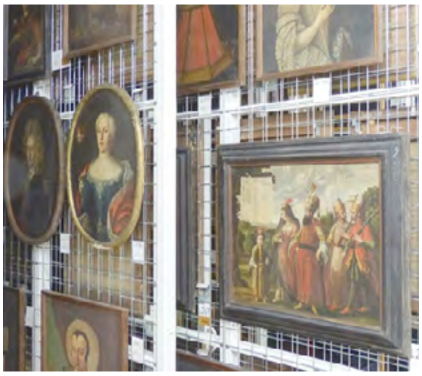
Base project »Designing Laboratories«

The starting point for our enquiry was the hypothesis that scientific progress goes hand in hand with a transformation of laboratory architecture. The results of our research have shown that the new image of the laboratory in the natural sciences has assumed the form of a communications centre. New demands have emerged on the spatial and organisational structures that aim to foster interaction and communication, in particular in interdisciplinary research in the natural sciences. Previous studies on laboratories were predominantly conducted from the perspectives of anthropology, sociology, architecture and history of science; the project complements these with an interdisciplinary study that investigates the laboratory as a historical, functional and spatial construct. Our research findings will be published in *New Laboratories* (de Gruyter, 2016). Some aspects of our work have fed into the design of the research building for IRIS Adlershof, the Integrative Research Institute for the Sciences.

Base project »Attention & Form«

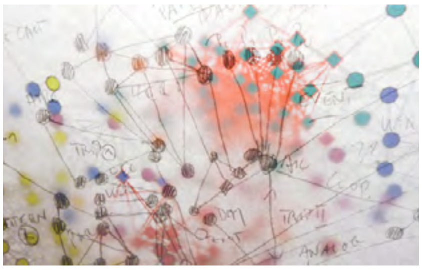
The base project seeks to develop an interdisciplinary concept of the perception and evaluation of form that combines the concepts from the different disciplines involved and confronts them with each other. Taking as its starting point morphological issues in biology and aesthetic phenomena in art and visual history, »Attention & Form« investigates the conditions under which form characteristics are seen as so significant for classification that they inspire the creation of a theory and the circumstances in which these classifications are subject to knowledge-dependent changes. To this end, it works in a trio with psychology to design new experimental set-ups in order identify the conditions and mechanisms that determine formal categorisation and concept formation, and to relate these to object properties, cultural and professional preconditioning and cognitive processes. The project enables both a transdisciplinary discussion of comparative methods and experimental processes as well as an examination of the selection criteria and formation of categories in the natural sciences and cultural studies.

Base project »Indexing of Collections«



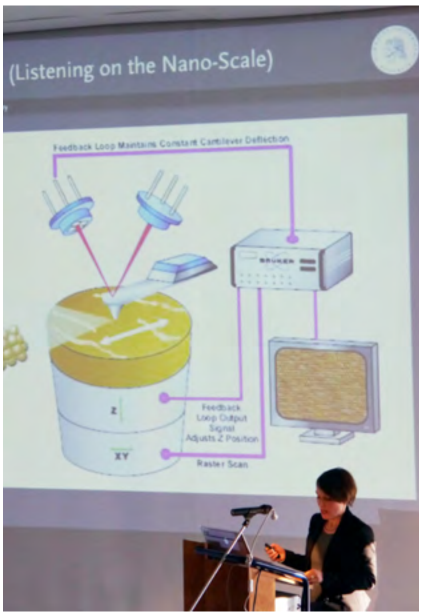
Taking as its test case an unresearched Berlin collection of paintings, the project uses this as the basis for modelling an interdisciplinary, virtual work environment that brings together approaches and methodologies from art and fashion history, computer science, materials research, conservation studies and interaction design. The project team members share an interest in gaining insights into the intellectual and technical conditions and processes that operate in this kind of collaboration and hence insights into what multidisciplinary indexing can achieve and how it is altered through the resulting concepts and applications. The objective is to make these findings productive for other subject areas and collections, and simultaneously to contribute to a broader understanding of the research object itself.

Base project »Shaping Knowledge«



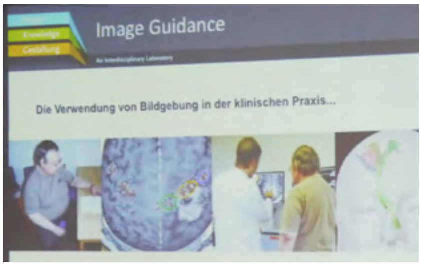
This base project focuses on how knowledge is generated, organised, and maintained, with a particular emphasis on images as complex cultural artefacts. From the perspective of information science, we investigate how visual information in various scholarly fields is produced, processed and how visual information transforms into knowledge (information in a social or semantic context). We ask for the ways in which the process of creative thinking (or art) and non-deterministic interpretation finally generates new knowledge and new information.

Base project »Analogue Storage Media«



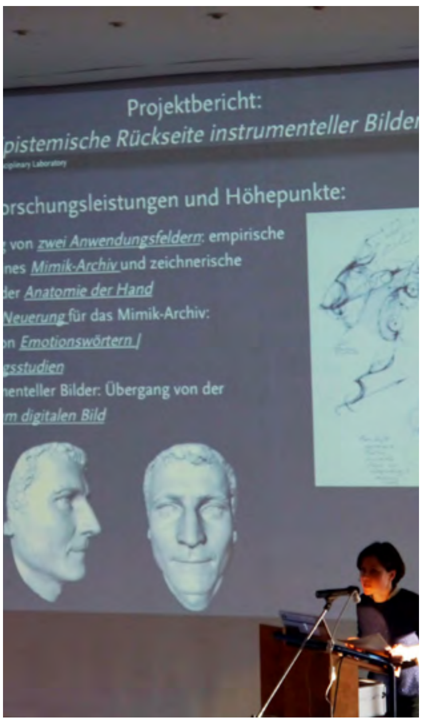
As a counterpart to the description of the modern age as a comprehensive process of digitalisation (of goods, information, practices, technologies, etc.), the base project proposes the thesis that culture eludes an opposition of »continual vs. discrete«, »real vs. symbolic« or »process vs. object«. Taking the audio record as its central paradigm, the project examined the storage function fulfilled by surfaces and structures on very different scales (from urban space to finds of prehistoric flutes all the way through to monomolecular graphene layers). It found that storage can be defined as a cultural practice that operates primarily as a haptic process through filter mechanisms; that is to say, a practice in which the act of storing is never separate from the act of transmission – at a purely material level. This view was confirmed not only through historical analyses but also in experimental set-ups and ethnographic studies of artists. Building on this research at a very fundamental level in the first phase of the project, a follow-on project was defined and a proposal submitted. It examines the Ancient Agora of Athens and the Roman Forum as sound storage media by creating simulations of both spaces using 3D modelling techniques and analysing them as acoustic structures.

Base project »Image Guidance«



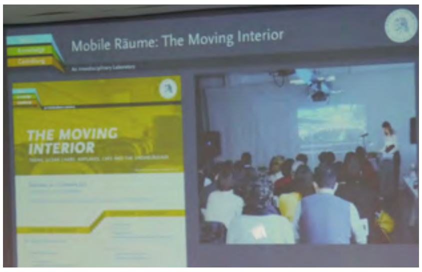
»Image Guidance« is an image-critical research project that, based on medical practice and the conditions of clinical interventions, develops proposals for the design of therapeutic processes and applications. At the project's core is the complex of visualisation practices that guide action as the interface between physicians and patients. They are investigated in case studies in order to be able to test and evaluate image-guided forms of operations in a dialogue with the fields of application and development.

Base project »The Epistemic Reverse Side of Instrumental Images«



The project examines instrumental images (images with which human actors act) focusing on the knowledge inaccessible to these actors from the creation of the images, such as open-ended research questions and unsupported concepts. Insofar as the respective visual form/technology influences the relationship between the functions of insight, representation and action that instrumental images assume, the manner in which the (non-)mediation between specialist research and application also changes with the images. Here the distance between the actors and the epistemic and image-theoretical conditions that operate in instrumental images increases with digitalisation. Exemplary objects include images from the fields of medicine and psychology that represent (1) the relationship between facial morphology and facial expressions and (2) the relationship between anatomy and function (in the hand). The interdisciplinary team is pursuing the following objectives: (1) to investigate the role of instrumental images in image-guided action focusing on the transition from drawing/schema to digital images based on two different cases and (2) to link epistemic knowledge with instrumental images by (a) developing alternatives to the Facial Action Coding System (FACS) for the database of facial expressions currently in construction at the Zuse Institute Berlin (ZIB) and (b) developing a platform (an atlas of facial expressions) with which questions and problems relevant to current research on facial expressions in science history and visual history can be made accessible to users from research, teaching and practice.

Base project »Mobile Spaces«



Architecture and design materially guide movements and actions in space. Conversely, mobility generates new forms of interaction with the material environment and the design of space. The base project's core objective is to re-analyse historical and contemporary forms of mobility in collaboration with archaeology, architecture, art history and product design. This will provide insights into the modes of interaction between space and movement, enabling the project to develop alternatives for experimentally reconstructing historical space-movement patterns and creating future space-movement patterns.

Base project »The Anthropocene Kitchen«

The »Anthropocene Kitchen« is based on the thesis that global processes are linked to individual actions in the Anthropocene era and can be clearly shaped by the sum of these actions. At its core is the kitchen as a familiar and significant (metabolic) interface between individual decisions and their global effects in the Anthropocene. With the kitchen as its focus, the project investigates interdependencies of food behaviour (in social and cultural practice) and architecture (spatial expression), and analyses and interprets the house-town-world structure. Its investigations examine the interdependent dimensions of food, historically evolved urban structures and the global Earth system. These three scales are investigated and represented in an experimental laboratory of the kitchen, based on Berlin as a case study, and in a global research study on which a participatory, intercultural science comic is based. The objective is to set out potential scenarios for a post-fossil future of food in the Anthropocene.

Base project »Genesis & Genealogy of Form«

This enquiry into the genesis and genealogy of form aims to describe from a comparative perspective how individual objects acquired their form (constructively and genealogically) by examining both the design of artefacts and the ontogenesis of organisms. Instead of focusing on the finished object, we conceptualise the genesis of form as a process or sequence of forms.

These processes may be immediately observable, but in many cases they require reconstruction. This is true for objects of biology as well as the objects of art history.

Base project »Science of Structures & 3D Code«

The long 20th century has left us with major structural revolutions and formalisations in engineering and the natural sciences and structuralism in the humanities. As a consequence of the new concept of active matter, these structures and in particular dynamic material structures have achieved a level of significance that goes far beyond the concepts in classical thinking on structures. It had led to a new understanding of matter as multidimensional code. Disciplinary and interdisciplinary experiments and studies on active matter and a dualism of code/matter (which merits further exploration) today provide the framework within which a new science of structures can be established as a humanities discipline and simultaneously a materials science. The priority project connects future-oriented research with historical perspectives, with the objective of establishing the criteria for linking different disciplines under the rubric of structures, thereby sketching the outlines of a new science of structures.

Base project »Mobile Structures«

The cross-base project working group »Mobile Structures« (MOS) was a spin-off from the project »Mobile Spaces«. The objective of MOS was, within a preliminary funding period of twelve months, to design a temporary experimental architecture that explores the connection between space and movement in an idiosyncratic manner. It aimed to interweave practical design processes with theoretical reflection as closely as possible and to capture the creative process itself as an exemplary form of interdisciplinary collaboration. The model developed of the »co-laboratory technicians« enabled the team to conceptualise space as an actor and to elaborate four hypotheses on it. These hypotheses will be experimentally tested in a walk-in spatial installation as part of the Cluster exhibition and made accessible to a wide audience.

Base project »Gender & Gestaltung«

»Gender & Gestaltung« represents the Cluster's aim of engaging seriously with categories of difference – first and foremost gender – not just solely at the level of diversity measures in line with DFG guidelines, but rather to apply their potential for insight productively in Image Knowledge Gestaltung. The central focus is how these categories have a shaping dimension in the production of knowledge and artefacts. The base project primarily examines boundary-setting processes that are signified by gender, their systematic similarities in the natural sciences and the humanities, their (naturalising) effects and the (experimental) production of evidence, their visual/medial institutionalisation and their material consequences – as a form of embodiment, in both the laboratory and the domain of politics.

Base project »Models in Gestaltung«

The base project examines the development and use of models in poietic processes, that is, in creative and cognitive processes in the sciences and scholarship, the arts and tangible design work, and in the process of the formation of social realities. A key point of focus is the significance of models in the visualisation of time-critical processes. In experiments, case studies and historic studies, poietic processes are investigated, forms of models identified, and the processes conceptualised on which the formation of models in different areas of knowledge are based. The project thus serves to promote an interdisciplinary understanding of design processes and also aims to lay the groundwork for a general theory of models in Gestaltung.

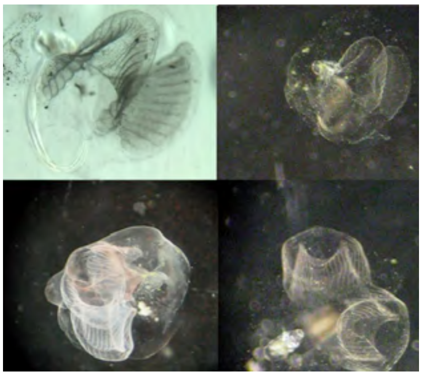
Base project »Picture Act and Physical Knowledge«

As a continuation of the base project »Picture Act«, this base project seeks to make a significant contribution to research on embodied forms of symbolisation, perception and knowledge. The project operates as a collaboration between biology, philosophy, and art and visual studies. At its core is the hypothesis that image perception entails motor activity that is controlled through the body schema. Within the priority area »Form Processes & Modelling«, which seeks to examine the interaction of form and perception, the project's task is to investigate the subpersonal processes in which the human body is instrumental through motor resonance.

Project »The Architecture and Morphogenesis of Biofilms«

Within the model system of bacterial biofilms, the central question examined by the project is how genes shape space in interaction with environmental conditions, that is, the question of the supracellular architecture and morphogenesis of these microbial communities, which behave like tissues. Biological construction materials (extracellular amyloid fibres and cellulose), whose cellular production is genetically controlled depending on the position of the cells in the biofilm, create a complex supracellular architecture and determine physical parameters such as cohesion and elasticity. These physical characteristics enable the biofilm to assume a three-dimensional form in diverse patterns visible to the naked eye. In addition to conducting molecular and cellular biological research on biofilms as a form of »active matter«, we also investigate the history of research on biofilms, starting with the ground-breaking study on what are now called pellicle biofilms of Bacillus subtilis by Ferdinand Cohn in 1877.

Base project »Self-Moving Materials«

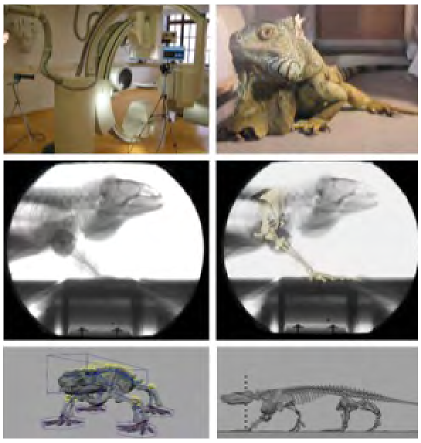


The priority project »Self-Moving Materials« investigates the structural connections and functional mechanisms in the complex, delicate filter-feeding houses in tunicates, juxtaposing them to filter structures used in architecture and machines and those found in other biological systems. Through experimental microscopic processes, digital/mathematical modelling of physical parameters and cultural-historical comparisons, it seeks to answer the question of how the organisation of structures in space can encode functional movement. Synthetic explanations of different, extrinsically coded processes of coming-into-being provide the basis for the intrinsic coding in structures, documented through image analysis. In cultural historical analyses, the project seeks to add a historical dimension to the relationship between code and matter in dynamic structures.

Base project »Gesundheit (Health) & Gestaltung«

The base project has set itself the transdisciplinary objective of redefining the stakeholder concept in relation to patients in the 21st century and the spheres of action in which they move. It researches and designs actual objects (such as the hospital bed, patient files, consent forms) and the associated practices as the interface between the treatment of chronic illnesses in clinics and beyond. At the same time, the researchers involved test innovative methodological convergences between theory, empirical studies and design and, in collaboration with the Charité University Hospital in Berlin, investigate new pathways and formats for evaluating and reflecting research results in the humanities and developed prototypes in clinical routines and research. »Gesundheit (Health) & Gestaltung« is conceived as a dedicated project that complements current research programmes in the life sciences.

Cluster Professorship »Morphology (Zoology) and History of Forms Working Group«

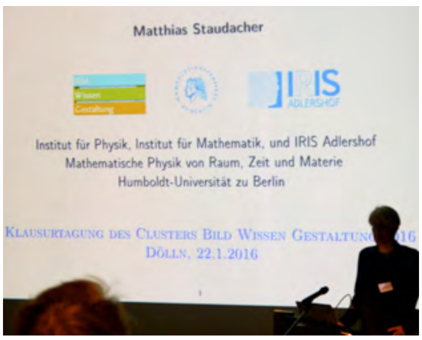


The »Morphology and History of Forms Working Group« is devoted to biological basic research on form/functional relationships and the evolution of vertebrates, whilst simultaneously reflecting on this research process with a particular focus on the images and models used it in. The intermeshing of research processes and reflection is made possible through the interdisciplinary composition of, and collaboration in, the working group, which is formed of representatives from morphology, illustration, philosophy, and visual and media studies. Collaboration here is seen as a dynamic process in which the different elements stimulate each other and as a process in which the methods and approaches applied in other disciplines are recognised and treated with respect. On this basis, the processes of generating and acquiring knowledge in functional morphology are investigated and reconstructed on different levels.

Base project »Matter of Typography«

The project »Matter of Typography« views and explores typography as a cultural technique that structures symbols as both carriers of meaning and material objects. Symbols only become carriers of meaning at particular sites, which are negotiated very differently depending on the cultural context. Following the model of a *longue durée*, it seeks to trace the development from the book to today's digital output formats. The project shows that design practices are always defined by their essential materiality, whilst materiality emerges as a medium in the first instance through cultural practices. The project builds on the work of its predecessor base project, »Pictograms«, which examined the role of pictographic symbol systems in different contexts. In particular, it explored the language for picture education developed by Otto Neurath, ISOTYPE, which aimed to communicate complex ideas simply, in contrast to abstract numerical and pictorial symbols in text structures. This language made much use of highly abstract pictograms. The relationship between the essence of symbols as images and the seemingly abstract information they visualise – and which they are intended to convey – is similar to their relationship to their materiality.

Cluster Professorship »Experimental Systems«

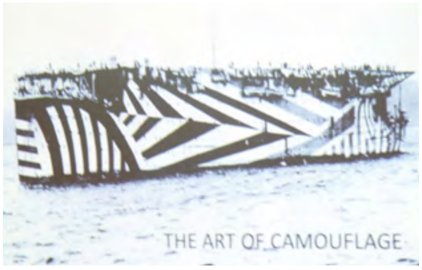


The project's goal is to bring together cultural studies and physics in an investigation of specific experimental systems, focusing on how knowledge production takes place, is promoted or hindered within them. The design, performance and documentation of experiments and the associated formulation of theories are elements of a historical development and can only be understood and examined in their wider cultural context. The project analyses case studies with an interdisciplinary approach, applying perspectives from anthropology, historiography, mathematics, philosophy and physics.

Project »gamelab.berlin«

gamelab.berlin sees the modern age as an era of games. This cultural theoretical thesis forms the basis for our interdisciplinary, multiperspectival research into the possibilities and limits of the "cultural technique of game-playing". How can this cultural technique contribute to knowledge-producing processes? Where and under what conditions can physical or virtual spaces of knowledge become realms of play where something new can occur? Given the complexity of the research questions it is investigating, the emerging working group *Gamelab* has since its beginnings in 2013 isolated specific questions and experimentalised them based on specific creative projects. The divergent projects are an intrinsic part of the group's programme. A synthesis will be provided in two overarching publication projects. Theorisation and historicisation complement each other in a diverse range of applications in prototype form, which in turn provide empirical data.

Cluster Professorship »History and Theory of Gestaltung«



Within the fields of research in Social Sciences and Humanities and, more specifically, in Philosophy, Art, Craft, Design and Industry, our base-project will focus on concepts such as (co)production, technique, interpretation, formation and »formativity«, body transformations, prosthetics, grafting, work, genius, »bricology«, »immatériaux«, invention vs. innovation vs. creativity. It will address different moments of the creative process and will tend to make sense of the relations between contemporary techniques, the field of »the living«, active matter and the production of forms, i.e. Gestaltung.

Seed funding project »Visual Gestaltung of Time«

Our everyday interactions with images are always influenced by time. An examination of the different visual proper times in images must include both the media conditions and their specific modalities of design. Applying a historical and systematic approach, the research project aims to explore how unique models and media conditions offer possibilities for the visual Gestaltung of time. A collaboration between design, design theory, history of art, media theory and philosophy will open up this previously unexplored area of research of aesthetic proper times, thereby bringing the modelling of temporal phenomena into focus. Such models can determine a knowledge of temporality that is in essence derived from visual designs.

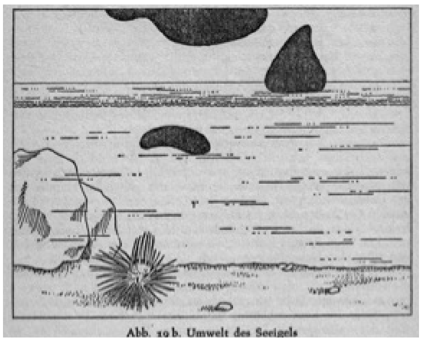
Base project »Mobile Objects«

The base project focuses on cultural and natural objects and investigates the contexts in which they emerged, their movements and their transformations. Objects were and are collected, classified, subsequently prepared and conserved. The object's state of maximal stability – with regard not only to its visible form, but also to its designation within a classification system – is confronted by a state of maximal mobility through different spaces of knowledge. Working on three subprojects in collaboration with different institutions housing collections, the project focuses on three dimensions of the mobility of objects: mobility in the context of the museum, the digital and political. By analysing exemplary forms of the (im)mobility of objects, the project seeks to describe interdisciplinary and transnational epistemic logics. Given its multi-institutional basis, the project aims to closely link actual object-related practice and reflexive research.

Seed funding project »Forms and Styles of Commands«

The project takes as its point of departure the thesis that commands – viewed as cultural techniques whose goal is their physical or mechanical implementation – model time. Commands often operate as a contraction of time, which may even appear to strive to eliminate time, but equally they can seek to extend the time between the issuing of the command and its performance. The project's goal is to develop a theory of commands that is grounded in sensory and media history, which will provide a framework for the description and comparison of these time-modelling processes. It focuses on three areas: military and bureaucratic organisation, the rearing and training of children and animals, and programming machines.

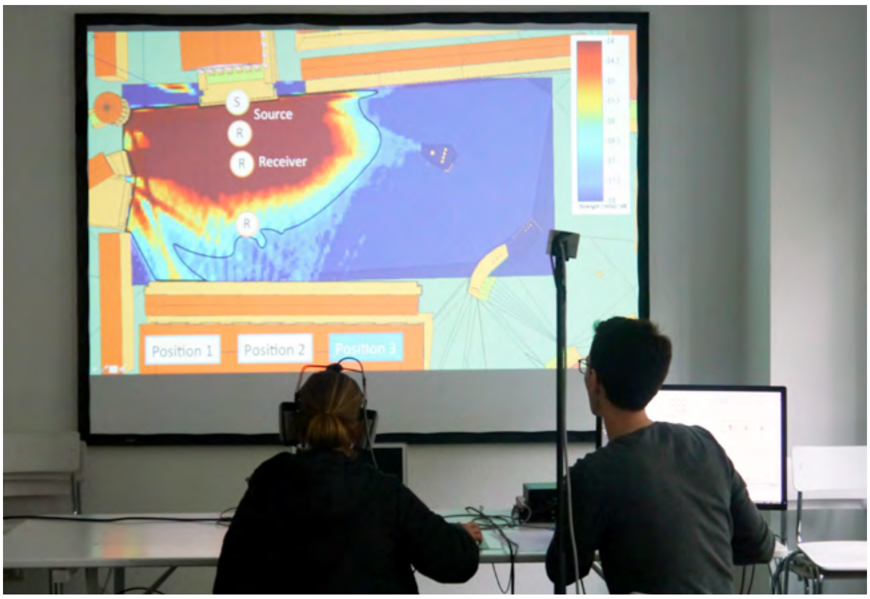
Seed funding project »Form-Code-Milieu«

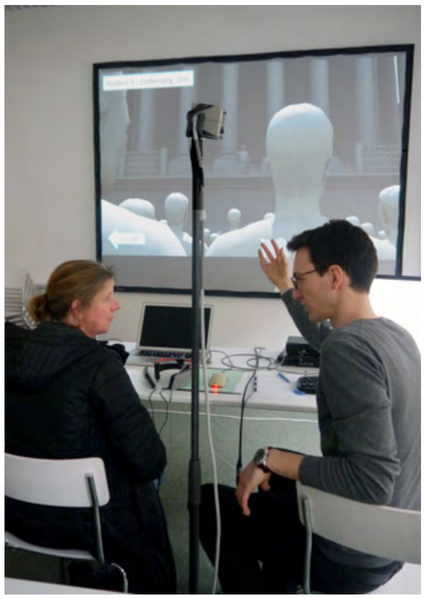


The new materialisms have led to the world as a whole being rediscovered as an unending material-discursive structure that yields from within itself all forms of the visible and utterable. Matter itself generates and stores information, and encodes, recodes, decodes and transcodes. Through these processes, matter forms its specific milieux. We define a milieu as the product shaped and informed by these processes, whist retaining milieu as a form of reference to the formless – as the milieu of all milieux. Working in collaboration with philosophy, mathematics and art and visual history, the research project's goal is to develop a materialist and processual theory of form, code and milieu.

Impressions Day of Sound

There was a chance to hear with a »stranger's ears« in the demonstration experiment in the sound laboratory. Binaural microphones were used to authentically convey the acoustic perception of a dummy head to visitors' ears. This technology is used in technical acoustics to isolate the so-called binaural room impulse response, which involves measuring the acoustic properties of a room with the aid of a dummy head.





Virtual acoustics also enables these authentic auditory impressions to be simulated for digitally modelled spaces. At the demonstration, visitors could listen to a Cicero speech from different listening positions in conditions close to the real experience in the historic Roman Forum.

Photos: Claudia Lamas Cornejo | BWG 2015

Workshop report »Matter of Typography«

Lead or haloes?

*On the relationship between digital and analogue typography**

The aesthetics, significance and function of symbols are a classic object of enquiry in semiotics. What kind of active influence is exerted by the symbols' support materials has scarcely received any attention. In the base project »Matter of Typography«, we examine this overlooked question as a shared research problem for computer science, cultural studies, design history and communication design. The core focus of our enquiries is typography as a cultural technique for structuring characters in space, characters which then simultaneously act as carriers of meaning and material objects. To date we have held three workshops where we have discussed the many facets of this interrelationship – material, technical, aesthetic – between representational materials and opportunities for creative expression with guests from different academic disciplines and fields in which typography is applied. Our discussions also examined the economic and social dimensions of typesetting as it would be impossible to understand type as a product or the material decisions taken by publishers or their design guidelines without considering these aspects.

From lead to light – from analogue to digital

The history of typography can be understood as the history of the craft techniques and mechanical processes for reproducing characters. In the 20th century, the design process for print products became a digital one, and digital presentation media assumed an increasingly important role. As a consequence, interest focused intensely on the abstract, mathematical description of the characters to be produced. At the same time, the haptic, visual and auditory properties of input and output media altered, for instance, in the form of screens on tablets, smartphones and monitors.

This is why we were interested in the workshop »Digital Typography« on the one hand in the programmability of typographical characters as an element of typeface and text design and its potential, which goes beyond the mere imitation of lead type. On the other hand, we discussed how the physical properties of electronically controlled output media influence the representation of written characters.

Wolfgang Coy clearly illustrated in his historical overview that the transfer of text design practices to the computer – and hence into the realms of the potentially automatable – was viewed as an arrogation and attack on the expertise in the printing press trade. Donald Knuth is a key figure in the history of digital typography whose aesthetics is inevitably much influenced by engineering. He wrote the first automatic typesetting system, TeX, and the abstract font definition language METAFONT, the first version of which appeared in the late 1970s. The very process of creating this language showed that it is immensely difficult to describe a character mathematically – in particular the letter »S« – in such a way that it still »functions« aesthetically in any vector scaling.[1]

The idea of automatically calculating the forms of characters ran counter to the practices of hot-metal setting as here a separate design was created for each font style (e.g. light, normal, bold), visually inspected and individually adjusted. How to find mathematical functions that completely remove the need for such corrections is a problem that still today has yet to be solved satisfactorily.

In macrotypography on the other hand, automating the balancing of line lengths for subsequent paper printing is a difficult task. As Patrick Gundlach explained in his talk

The digital construction of characters using vectors with anchor and curve points. Photo: Dan Reynolds | BWG 2015 on the automation of typography, the programming language TeX provided the first algorithmic solutions to this problem, which only required minor manual adjustments. Since the 1990s, the Portable Document Format (PDF), created by Adobe Systems, has been an established means for maintaining the fixed design of a paper page in a digital format. The PDF enables »layout fidelity« and is freely portable to different computing systems. Content and form can be integrated in a PDF as they are in paper-based practice. With electronic output media by contrast, dealing with the dynamic nature of the output medium – the resolution and scalability of which is limited – is the decisive issue. The modern paradigm of markup languages entails a separation of the formatting from the logical/structural markup of the text (known in the jargon as the »semantic« markup). Examples include the interaction of CSS and HTML.

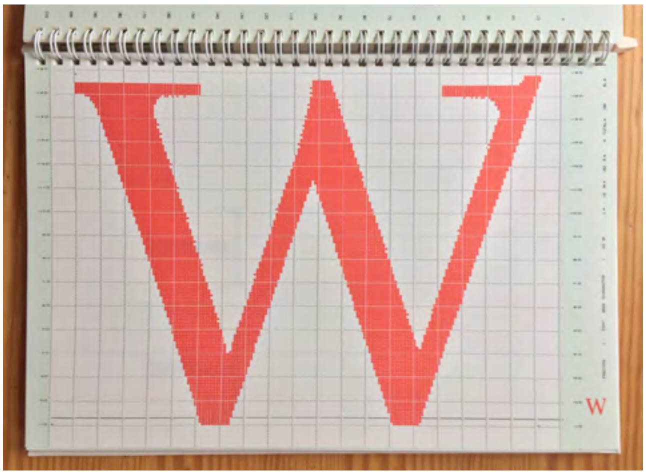


Image of a character formed of pixels.
Photo: Dan Reynolds | BWG 2015

Instead of formally describing a document using a programming language in a text editor, today designers generally use font editors such as Fontographer or typesetting applications such as InDesign with graphic interfaces. These resemble the drawing boards used by technical drafters. They mediate between the algorithms and the analogue graphic design practice. But here, too, the changes ushered in by digitalisation are visible: at the workshop »Co-production and Digitalisation of Design«, the typeface designer Dan Reynolds demonstrated how digital design is inscribed in the shape of type. The digital construction of characters with different stroke weights involves a complex transfer from a surface shape, originally created manually with a broad-nibbed pen stroke, into a vector graphic or outline form. The character becomes a data-rich configuration of straight and curved lines within a system of coordinates. This enables, firstly, lines to be copied exactly, and formal consistency within the typeface is easier to achieve. Secondly, character combinations can be displayed and checked faster and with greater ease.

Despite these changes, conservative forces dominate text and typeface design. Just as many digital typefaces are made to resemble their printed archetypes as closely as possible, the digital imitation of text on paper was and is the seemingly unattainable measure of all things, as Martin Warnke noted in his talk »Paper Simulations« at the workshop »Digital Typography«. It has been the case for some time that pixelisation on HD output media and Retina displays is below the threshold of perception so that the simulation of paper no longer presents an obstacle, at least for text representation. Similarly, the problem of high latency times when producing handwritten texts and the quality of recognition when these are converted into digital character sets appears to have been solved with the latest tablet devices by various manufacturers.

The workshop »Type and Light« took a look back at the analogue beginnings of the processing of type through the medium of light in phototypesetting in the 1950s. This showed clearly that the first paradigm shift in typography in the 20th century did not occur with digital typesetting but with the fundamental, material shift from lead to light. Furthermore, the analogue manipulability of light prepared the ground for digital technologies and practices as light enables characters to be manipulated with similar freedom from real-world, material constraints.

Until today, light remains one of the key players in the creation of analogue and digital typefaces. Whereas previously an analogue phototypeset image had to be developed so as to provide flat film templates for the prepress stage in offset printing, digital display technologies today work with an immense variety of physical and chemical light modelling processes. The introduction of organic light-emitting diodes in particular has paved the way for wafer-thin, flexible support media, as the photonics researcher Norbert Frühauf demonstrated in his talk. In the foreseeable future, the page of text as a haptic/flexible medium, which has been intrinsically bound to paper for centuries, will reappear in typography as a transparent surface that can be described through the medium of light.

The discussion with phototypesetting experts Eckehart SchumacherGebler and Hansjörg Stulle, who owned leading typesetting workshops in the 1960s and 1970s, was an

Berthold diatronic matrix plate used in phototypesetting.
Source: Wikipedia

opportunity to examine the practical, aesthetic and economic consequences of this then new typesetting technology. On one hand, the possibilities for optical manipulation in phototypesetting resulted in greater scope for creativity, in particular in titles and headlines, which are important in advertising typography. On the other hand, this resulted in problems in the production of the body text, which no longer corresponded to the aesthetics of hot-metal setting. Typefaces, previously cast in lead sorts, type sizes and letter-spacings could now be modified with great flexibility, generating extremely variable text-images.

The usefulness and performance of phototypesetting in text production was measured by the extent to which it was able to convey as closely as possible the quality of the typeface found in hot-metal setting. Here parallels can be drawn with the oft-repeated criticism of the displeasing aesthetics of e-books.

Economic and social aspects

The digitalisation of typesetting and printing not only makes the mass reproduction of documents possible, a process that began with Gutenberg's invention of movable type; it also makes design tools more accessible. Lead and printing machines were heavy and fixed in one place, where a social division emerged between typographers as an exclusive professional group and non-typographers. Typesetting and reproduction were activities not open to all social groups. The cheap, mass reproductions of pamphlets using hectographs or school newspapers produced with cut-and-paste layouts and then photocopied may be historical counterexamples, but they never posed a serious threat to the high-quality and highly differentiated text reproduction in the printing trade. Digital technologies have overcome this material immobility and simultaneously eliminated printing shops as the legitimate centres of typography. Today typography is a location-independent cultural technique and accessible to considerably larger sections of society than ever before.

Career paths in design, typesetting, printing and sales were and are subject to constant evolution as a result of the continuing shifts in design and production tools. Professions such as compositors and paste-up artists have disappeared and been replaced by others such as media designers. The easy access and user-friendliness of digital typesetting programmes has also led to a decline in traditional typographic standards. Previously this knowledge was handed down with the craft practices of the letterpress printing trade, as print and typography experts Eckehart SchumacherGebler, Hansjörg Stulle and Jörg Behrens remarked. They noted a link between the declining quality of print products and the disappearance of traditional printing methods. The debate about whether this is a case of a profession protecting its vested rights and authority or whether basic, general training in aesthetics is needed before anyone can start designing text media is highly relevant today. It also leads into the question of whether the implicit knowledge in letterpress printing is a form of intangible cultural heritage that is worthy of preservation.

Not only do increasing numbers of people have access to design as a result of the widespread availability of digital media and the related software – more and more people are demanding it, too. The design process is now a co-production between designers, mediators and recipients, which has transformed and significantly accelerated this process in recent decades. Authors are now often called upon to either design their books themselves or work in templates. Typefaces are no longer designed solely by trained experts; they are no longer sold by type foundries and the result of their selection criteria; instead typefaces are now sold via online platforms (mostly without quality controls).

The digitalisation of typeface design and, above all, the potential to disseminate print-like products online were met with euphoric visions of the potential to democratise and personalise the design processes – individual designs by everyone, for everyone, are now possible.

But can we really speak of democratisation when authors handle proofreading, book design, marketing and sales, or is this merely the consequence of the pressures of rational-

Large type body matrices by Monotype, photographed in the type archives of Offizin Haag-Drugulin Graphischer Betrieb GmbH in Dresden. Photo: Christian Kassung | BWG 2016

Pushbutton keyboard on a Monotype typesetting machine for producing punched tape, photographed at Offizin Haag-Drugulin Graphischer Betrieb GmbH in Dresden. Photo: Christian Kassung | BWG 2016

isation and publishing? This remains a controversial issue. What is more, clear limits are placed on design freedom from the outset due to brand rights and copyrights. Typefaces remain goods, even in digital form.
Yet software developers and technology hobbyists have developed design and business models that make community-designed or -maintained and freely available fonts possible. Philipp Poll gave us insights into this creative process, focusing on Linux Libertine and Linux Biolinum, two typefaces he designed. However, there is hardly any interaction between the community of highly specialised typographers and the open source software scene. Is there a fear of contact, as there so often is in the world of intellectual property, because the autodidacts call an entire profession and traditional business models into question?

Conclusion

The following questions on the relationship between materiality and the design of symbols in typography have emerged from the varied discussions in the workshops:

1. The technical and material prerequisites for hot-metal setting in conjunction with paper marked out the boundaries for a highly differentiated aesthetic canon. All subsequent analogue and digital typesetting technologies – from phototypesetting to digital typesetting – have adapted these. The design rules implicitly inscribed in the practices of the traditional craft – which were considered guarantees of »pleasantly readable« texts – were transferred to other media environments. To date, there has not been sufficient reflection on the new physical parameters and the characteristics of user and reading behaviour today, which has undergone a spatial and temporal transformation.

2. The flexibility with which characters can be composed in digital typography is different to that which prevailed in analogue typography: the formal descriptions of characters using curves, vectors, surfaces or points are variable to the extent that they remain manipulable during electronic output or during reading. Up until now, typographical design aimed to achieve a static output text and to render the support material passive. What would happen if the producing and representing material – such as the design logic implemented in electronic circuits and code, the screens, the printed supports and similar elements – was seen as an active element? A digital, responsive typeface should integrate the material properties of different output media, different lighting conditions, individual reading and design needs, and the interaction of image and/or sound in its programming. In reality, however, this kind of scalability in type design still encounters many problems.

3. The intangibility of digital typefaces is directly correlated to their (virtually) unrestricted reproducibility from one computer to the next. Compared to the type case archives in letterpress printing, which were as heavy as the lead they held, they seem to take up hardly any physical space. But their materialisation and preservation requires an electronic infrastructure that is anything but virtual, requires considerable energy and is subject to rapid innovations. The file formats in which typefaces or designed texts are stored, the data carriers, design software, screens and computers are themselves anything but timeless. So-called digital preservation raises considerable problems: finding suitable storage formats that will remain compatible for centuries, developing highly redundant backup concepts, not to mention resource consumption. The electronic scrapheaps on Earth show clearly just how non-abstract actual silicon-based circuitry is. The need for greater emphasis

on the physical qualities of computer technology and its temporality is an explosive issue, in particular for the design of technology.

A Look Ahead

All the workshops have shown us that close links with external representatives from design practice are essential for our analysis of the issue of materiality in typography. Through our discussions with practising professionally printers, we have come into contact with a highly topical discourse: the issue of the value of preserving letterpress printing, given that an immense body of implicit knowledge risks being lost with the last trained experts. For us, this profound break raises questions of how analogue and digital text production media have interacted historically and continue to do so today, and the extent to which preserving analogue typesetting and printing techniques could be productive not just for our understanding of digital typography but also for its further development. We take as our point of departure the thesis that letterpress printing must not be seen as an anachronistic cultural technique that is disappearing into our historic fund of knowledge as a craft which has become »obsolete« in the course of the digital revolution. Instead we see the individual methods and practices as having been transformed time and again into other media, a process that continues until today. Hot-metal setting continued structurally as phototypesetting and later digital typesetting with its formatting.

These »Transformations in Letterpress Printing« will be the focus of a two-day conference on 9 and 10 June, which we are organising in collaboration with the Dresden printing office Offizin Haag-Drugulin and the international Verein für die Schwarze Kunst (Association for the Black Art).

*If two printing plates do not align precisely, unsightly white gaps known as »haloes« can appear on the page where the two colours should meet exactly (as can be seen in the headline). Haloes can also appear on the edges of the page when trimming.

† Donald Knuth: The Letter S. In: The Mathematical Intelligencer, Vol. 2–3, September 1980, p. 114–122.

Andrea Knaut
Base project »Matter of Typography«

Julia Meer
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Katharine Walter
Base project »Matter of Typography«

Newton, Spock and Einstein: From fake planets to real gravitational waves

On 12 February 2016, the LIGO Scientific Collaboration and the Virgo Collaboration announced that they had experimentally validated gravitational waves for the first time.[1] *The existence of these waves or »ripples« in space-time is a necessary consequence of Albert Einstein's general theory of relativity and was predicted by the physicist one century ago. But what are these waves actually? What is the theory of general relativity all about? And what would Newton think of it? A closer look in three parts.*

»What if... « were probably Edmund Halley's first words when he, Robert Hook and Christopher Wren in 1684 asked how the planetary orbits could be described mathematically if the force that imposes this orbit on the planets is in inverse proportion to the square of each object's distance from the sun. This kind of dependent relationship suggested itself if Christiaan Huygens' law of centrifugal force, set out a few years previously, was interpreted in line with Kepler's third law. What would the orbits of the planes look like? Could such an interpretation describe the observed movement of all celestial objects?

Unfortunately, none of these three men were able to solve this mathematical problem, and Halley passed the question to the natural scientist Isaac Newton, who was based at Trinity College, Cambridge. In November 1684, Newton sent Halley his short, nine-page answer, *De motu corporum in gyrum*. Newton showed that, assuming an inverse-square law of force, the planetary orbits would be elliptical under certain circumstances. He thereby provided a mathematical derivation of Kepler's laws, which the German astronomer had found empirically 80 years earlier. The end result of these investigations is none other than Newton's book of the century, *Philosophiae Naturalis Principia Mathematica*, which was completed in 1687 with the third book, *De mundi systemate*, and explains all the results observed in the universe up until that date according to Newton's mechanics. But could new predictions be made based on his work?

Fortunately, Gottfried Kirch had not only discovered the first comet using a telescope a few years earlier, in 1680, but also spotted another celestial object that moved amongst the heavens in a curious manner on a parabola. On such an orbit, »Kirch's comet« would have to emerge from the infinity of space and disappear once again into that same infinity. With three data points from the comet's observed path, Newton used his mechanics to minutely reconstruct its parabolic path and concluded: »The theory that corresponds exactly to so nonuniform a motion through the greatest part of the heavens [...] cannot fail to be true.«[2] To put it in the language of physics today, we might say that Newton had found the theory of everything. It is a shame that this »everything« in the 17th century was a universe that only extended from the sun to Saturn.

Image 1: Lieve Verschuier: »The Great Comet of 1680 over Rotterdam«, (1680). »Kirch's Comet« could be seen with the naked eye as it approached the earth and was exceptionally bright.

William Herschel mistakenly believed that he had seen a comet in 1781 when he was searching the heavens at night with his telescope for double-star systems. The object in his focus appeared as a disc with a cone angle and not as a point, as would have been the case with a star. His strange comet also seemed to follow a curious, almost circular path around the sun. It turned out that Herschel had not discovered a comet but – purely by chance – a previously unknown planet: Uranus. This offered an opportunity to put Newton's mathematical representation of reality to a challenging test. How would his theory stand up in the realms of the unexpected and unknown? As Uranus takes more than 84 years to orbit the sun, there was still some time to wait before this could be investigated precisely.

In the meantime, Pierre-Simon Laplace devoted himself to developing an improved mathematical method for calculating celestial orbits within Newtonian mechanics. He created a comprehensive calculation method that showed how the objects in the known cosmos should behave. To his surprise, his results did not correspond to all the observations. For instance, Jupiter appeared to have been moving faster in the previous decades than the laws permitted. Saturn on the other hand simply took too much time to orbit the sun. Was Newton's theory actually not infallible? Or had some fact been overlooked and had to be added to the theory? Laplace quickly found the key to the puzzle himself. The apparent difference between the mathematical predictions and observations was due to the strong influence that Jupiter and Saturn exerted on each other when they passed near each other. This effect could be explained with the help of perturbation theory and had to be included in Laplace's calculations in order to bring his predictions in line with observations. With the increased accuracy of his differential equation systems, he also asserted that this effect – the acceleration of Jupiter and the slowing of Saturn – would recur every 929 years. He thereby introduced an unimaginably long timescale for an empirical verification. And Laplace was right. By analysing astronomical data from the previous two millennia, he was able to show that there was empirical evidence to support his prediction. Between 1799 and 1825, he wrote his five-volume masterpiece, *Mécanique Céleste* (Celestial Mechanics), which explained all the phenomena of the heavens. He showed that the entire dynamics of the known solar system was based on Newtonian mechanics. The universe had become deterministic.

Despite Laplace's supposed solution of the question of celestial mechanics, Urbain Jean Joseph Le Verrier felt himself called upon in 1837 to calculate the planetary orbits once more with even greater accuracy under the pale glow of his desk lamp. First he set to work on the four inner planets, Mercury, Venus, Earth and Mars. In a few years, he had produced datasets for their orbits more precisely than ever before. Le Verrier must have been surprised when, during a transit across the sun in May 1845, Mercury moved into the disk of the sun 16 seconds later than he had calculated. No doubt disappointed about this small but unexplainable discrepancy, Le Verrier set the problem aside for the time being and turned his attentions to the other extremity of the known universe: Uranus.

Since its discovery, the planet had almost completely rotated the sun once. But here too, Le Verrier was unable to get his calculation to match the limited data collected since 1781. The observations did not correspond left, right and centre with Newtonian mechanics, and the problem could not be solved with greater precision and more terms in perturbation theory. Was Newton's theory actually not infallible? Or had some fact been overlooked and had to be added to the theory? If so, what? Accuracy and precision were not the issue here, in contrast to Laplace's problem. But could more perturbation be incorporated into the system?

Alexis Bouvard had been closely observing Uranus for a long time and proposed around 1845 that the peculiarities in its orbit could be due to another as yet unknown planet on the other side of Uranus. This idea was taken up by Le Verrier and, quite independently, by John Couch Adams. Le Verrier packed all the inconsistencies in the orbit of Uranus into his calculations of the orbit parameters of this unknown planet. He presented his solution on 31 August 1846: with a good telescope, it should be possible to see a new celestial object five degrees east of δ *Capricorni* and at an approximate distance of 36 astronomical units. It should be visible as a disc of 3.3 arc seconds.[3]

It remains unknown why no one in the French astronomical community felt called upon to verify Le Verrier's prediction. Annoyed at his compatriots' ignorance, he wrote a letter to the young astronomer Johann Gottfried Galle at the New Berlin Observatory on 18 September 1846. Galle received the letter five days later and set to work that night. Around one in the morning, he saw what Le Verrier had predicted: a disc of 3.2 arc seconds, only a tiny degree away from the position that Le Verrier had indicated. An unknown planet never seen by a person before, later to be named Neptune. A triumph for Newtonian mechanics. A planet that had been discovered not in the light of the heavens but in the light of a desk lamp. A triumph for Le Verrier.

Following this splendid success, he was appointed as the director of the *Observatoire de Paris* in 1854, giving him considerable influence on the programme of astronomical research in France. Now it was time to return to the problem he had set aside ten years ago and settle his accounts with Mercury using all the means at his disposal. The improved studies, observations and calculations of the orbits of the inner planets showed that three of the four inner planets behaved exactly as they should do. It was only Mercury that stubbornly defied the laws of nature. At least the problem could be set out with great precision. Based on the observations of Mercury, the point in its orbit at which it is closest to the sun, its perihelion, could be determined very precisely. Over one hundred years, its perihelion moved 565 arc seconds in the direction of Mercury's orbit. When the influences and perturbations of all the other planets were included in the two-body problem of the sun and

Mercury, this produced a theoretical value of 527 arc seconds for its perihelion precession. According to Le Verrier, the difference between these two figures amounted to a trivial 38 arc seconds in one hundred years.[4] An almost insignificant value but still large enough for the calculations of the transit of Mercury in 1845 to be 16 seconds ahead of the actual start. But above all it was a value that called

Image 2: Carl Daniel Freydanck: »The New Berlin Observatory«, (1838). The observatory was located close to what is today Mehringplatz in the Kreuzberg district of Berlin.

the cosmic order into question. The difference was inescapable, and there was no explanation for it in Newtonian mechanics. Or was there?

Why shouldn't the same idea that had worked so brilliantly a few years previously with Uranus also be applicable to Mercury? Could perhaps another mass between the sun and Mercury be the cause of the inexplicable peculiarities in the planet's orbit? Le Verrier was convinced that another small, unknown planet or – as it would have been difficult to explain why it had not been seen before – a group of asteroids was up to some mischief between the sun and Mercury. He reported this in the September issue of the *Comptes rendus de l'Académie des sciences* in 1859. Shortly after his report reached public attention, Le Verrier received a letter from Orgères-en-Beauce from a certain Dr. Lescarbault. Dr. Lescarbault said that, alongside his duties as a practising physician, he devoted his leisure hours to astronomical observations of the starry heavens. A few months earlier with a home-made instrument, he had observed an unknown object about a quarter the size of Mercury as it stealthily passed once across the disc of the sun on 26 March 1859. He had not yet told anyone of his sighting, Lescarbault continued, as he did not want to try to explain his own observation. A light suddenly dawned on him when he read Le Verrier's report.

Full of hope, Le Verrier travelled to Orgères-en-Beauce as fast as possible to take a close look at the doctor and his instruments. Could this amateur be trusted? What he saw on his arrival was far from the scientific standard. Unfortunately, Lescarbault had only recorded a few measurement points for the transit as he had to treat patients in between observations. He stated the accuracy with which he observed the object's movement in seconds although he did not have a single clock in his entire house that could measure time more accurately than in minutes. Lescarbault only had a pendulum and, as he put it himself, a physician's ability to count seconds very precisely when taking a pulse. Despite the questionable circumstances in Lescarbault's hand-built observatory, Le Verrier was convinced of the doctor's credibility.

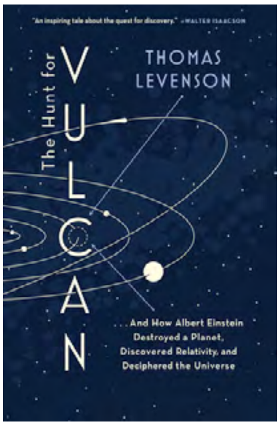
Le Verrier quickly calculated some properties of the orbit of this mysterious celestial object, based on the limited data from the sketchy observations. The object followed its paths through the heavens in such a way that directly observing it was almost impossible. But during a solar eclipse or another transit, an intensive search should solve the last puzzle in the Newtonian cosmos. With Le Verrier as the prominent representative of this idea, the solar system gained a new planet. As this planet was constantly exposed to the fiery glow of the sun, there was never the slightest doubt as to what it should be called: Vulcan. The Roman god of fire. That there had not been any rigorous, systematic observation of it to date was but a minor detail. Everything was just a question of time.

Once Vulcan had been lifted from the fires of the sun, the reports of chance observations of the planet started to increase, from the ranks of amateur and expert astronomers alike.[5] Older astronomical data was reinterpreted as earlier sightings of this celestial object, as it had originally and incorrectly been believed to be an example of a sunspot or similar phenomena. Until Le Verrier's death in 1877, these chance reports and observations fed off each other, although a scientifically recognised confirmation failed to materialise.

The total solar eclipse in July 1878, which cast its dark shadow right across the USA from Montana to Louisiana,[6] was one of the last systematic attempts to find the ephemeral object. Scientists set up their telescopes in the dust of Wyoming to scan the suddenly darkened sky for two minutes and fifty-six seconds. Of all them only James Craig Watson, the director of the Ann Arbor Observatory in Michigan, believed that he had seen Vulcan. But he could not convince anyone of his finding. The firm belief in this planet, moving in the eternal flames of the sun, was gradually swept away with the sands of the American West and would disappear completely in years to come. Vulcan only remained as the fictional home of an exceptionally unemotional humanoid species that lives strictly by reason and logic. Sadly, their planet would be short-lived: it was destroyed by the Romulans with a black hole.[7]

But Mercury still did not follow the path that Newtonian mechanics predicted for it. Far from it: its eccentric behaviour was calculated with even greater precision, resulting in a perihelion precession of 43 arc seconds in one hundred years. It goes without saying that there were other attempts to find a perturbing mass hidden between the sun and Mercury. Perhaps the sun was flattened and its uneven distribution of mass was making its closest planet to spin? Or maybe invisible rings, similar to the rings of Saturn, passed through the space between the star and its closest planet? None of these attempts at an explanation could be sustained for long. All that remained at the end was the bitter realisation that no explanation could be found for Mercury's eccentric behaviour in Newton's inverse-square law of force. The problem was tucked away in a drawer for the time being. Only several decades later in November 1915 did Albert Einstein dare to appear before the world with a new solution. One that would have momentous consequences. Continued on the next page.

Part 1 – based on Thomas Levenson »The Hunt for Vulcan«, Random House 2015.



[1] B. P. Abbott *et al.* »Observation of Gravitational Waves from a Binary Black Hole Merger.« Phys. Rev. Lett. 116, 061102 (2016).
[2] Quoted in Levenson, Thomas: »The Hunt for Vulcan.« Random House 2015. p. 33.
[3] An arc second is a unit of measure for an angle and corresponds to 1/3600 of a degree.
[4] According to these calculations, the perihelion of Mercury would return to its original Newtonian starting point every 3.4 million years.
[5] Fontenrose, Robert. »In Search of Vulcan.« The Journal for the History of Astronomy iv (1973), 145-158.
[6] Eddy, John A.: »The Great Eclipse of 1878.« Sky and Telescope, Vol. 45, No. 6, June 1973.
[7] »Star Trek«. Director: J. J. Abrams. Paramount Pictures, 2009. Film.

Stefan Zieme
Base project »Experimental Systems«

Newton, Spock and Einstein: From fake planets to real gravitational waves

Continued

Perhaps Albert Einstein stumbled hastily along Unter den Linden in Berlin on 18 November 1915. But maybe he walked with poise, pensive, as he was well aware of the significance of the lecture he was about to give. In any case, his objective was Number 8 Unter den Linden, which housed the Royal Prussian Academy of Sciences. He was already familiar with the route to the academy. After all, he had already reported to the academy's two previous Thursday meetings in November 1915 and was to speak on this coming Thursday in order to complete his great coup. But on this day he had something quite exceptional to share with the academy. Based on the equations of his general theory of relativity, which he would only finalise a week later, he could already derive a first result by approximation: »This calculation yields, for the planet Mercury, a perihelion advance of 43" per century, while the astronomers assign 45'' ± 5'' as the unexplained difference between observation and the Newtonian theory. This theory therefore agrees completely with the observations.«[1]

Einstein had found a solution to the problem that had haunted physics and astronomy for five decades since Le

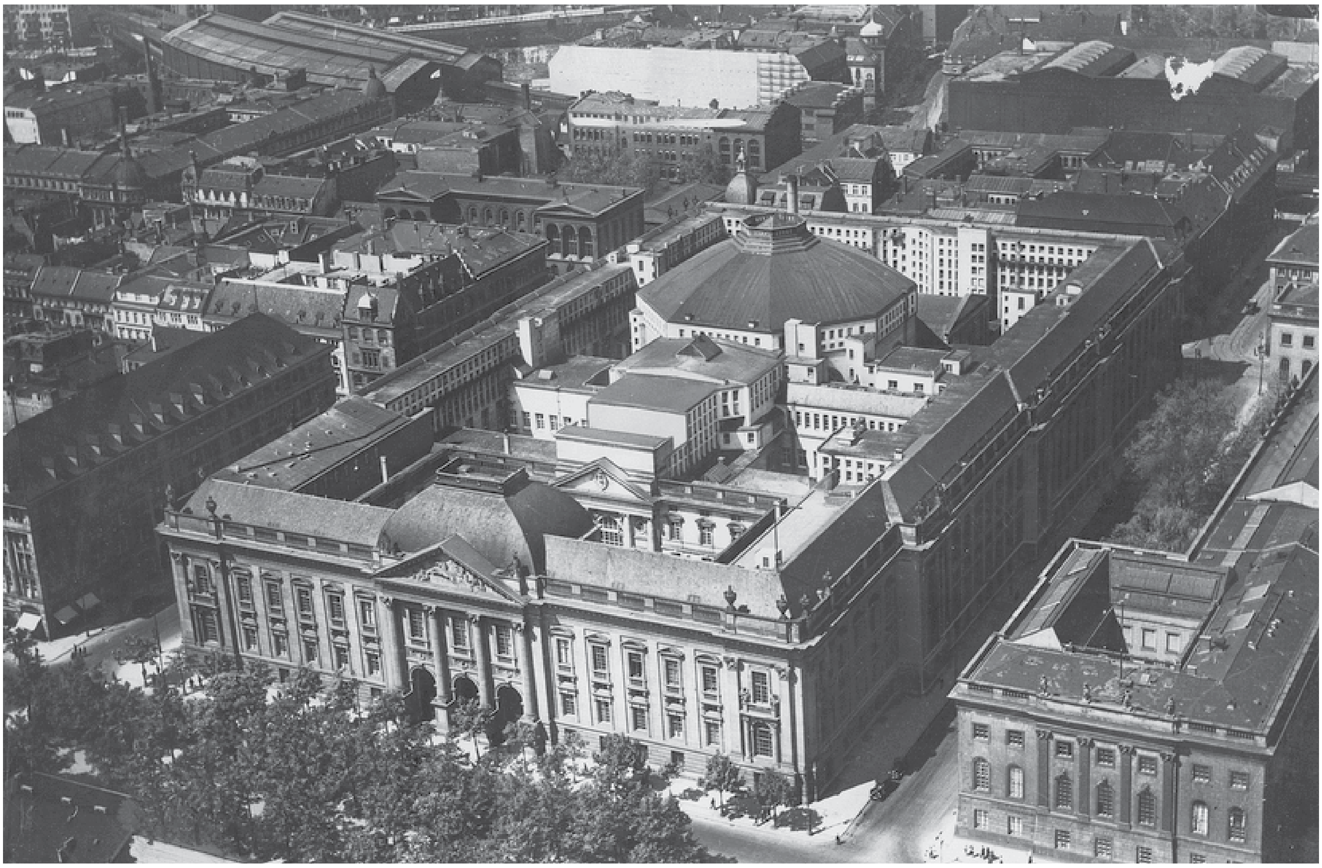


Image 1: View from the south of the Royal Library, 8 Unter den Linden. Aerial photograph from the 1920s. In Einstein's time, the Royal Prussian Academy of Sciences had its offices in the library, which was inaugurated on 22 March 1914.

Source: Staatsbibliothek zu Berlin.

Verrier's time. Countless numbers of people had exposed themselves to the danger of burning their retinas in vain trying to discover the secretive planet Vulcan on its orbits of the fires of the sun. It simply did not exist. And there were also no mysterious asteroids, no flattening in the sun's surface and no »jumps« in the gravitational constant. Newton's universe was simply and poignantly incorrect – or at least not quite correct at any rate.

Space and time are not absolute, and massive objects do not move in them as the result of some instantaneous, sudden distant effect. Instead space-time, a term coined by Hermann Minkowski to combine space and time in a four-dimensional unit and which forms one of the essential elements of Einstein's theory, is dynamic. It curves and bends under the influence of the mass and energy that is spread across it. The local geometry of the universe is not Euclidean but as curved and bent as Bernhard Riemann formulated it purely mathematically and abstractly in Le Verrier's time.

The objects moving in the cosmos only follow one objective in their orbits: the shortest and fastest connection in a curved space-time. And as they move, they themselves bend space-time in their immediate surroundings with their mass and energy. Everything is in motion; everything is dynamic and extremely non-linear. This is what Einstein's field equations described. Or to put it more precisely: the difference between the Ricci tensor and half the metric multiplied by the Ricci scalar equals the stress-energy tensor. The stress-energy tensor must be multiplied by eight times Pi and the gravitational constant and divided four times by the speed of light in order to include Newtonian gravity as a non-relativistic marginal case. This was what Albert Einstein told the Prussian Academy on the last Thursday of the month, 25 November 1915. These were his final equations that describe the phenomenon of gravity in the universe. Based on these equations alone, he had calculated Mercury's movement precisely before his speech.

The reason for Einstein's staggered announcement was not the global political situation but quite mundane: the fear that David Hilbert, a mathematician from Göttingen with whom he had spoken in-depth and openly about his ideas shortly before, would be quick on his heels.

Just a few days after Einstein published his November reports, he received a letter from Karl Schwarzschild, the director of Potsdam Astrophysical Observatory. However, these lines did not come from Potsdam itself but arrived with the military postal service from the Russian Front, where Schwarzschild had volunteered for duty. »In order to become versed in your gravitation theory,« wrote Schwarzschild, »I have been occupying myself more closely with the problem you posed in the paper on Mercury's perihelion and solved to 1st-order approximation.«[2] Schwarzschild went on to write that he had found a complete solution to the problem. But this only resulted in a difference of a billionth to the orbit Einstein had obtained by approximation and was therefore »practically absolutely irrelevant«. For Schwarzschild, it was »a wonderful thing that the explanation for the Mercury anomaly emerges so convincingly from such an abstract idea.« Schwarzschild's »irrelevant« contribution was the first complete, spherically symmetrical solution to Einstein's field equations. It would later be recognised as characteristic for black holes, but for now it served to explain Mercury's orbit, and the planet Vulcan was definitively ruled out.[3] At the end of his letter, Schwarzschild remarked: »As you see, the war is kindly disposed toward me, allowing me, despite fierce gunfire at a decidedly terrestrial distance, to take this walk into this your land of ideas.« Five months later Karl Schwarzschild died of a rare skin disease that he had caught in the trenches.

Einstein's »land of ideas« had solved a long-standing problem and resolved a seemingly inexplicable anomaly. But it could also produce new knowledge? Could Einstein's theory make further predictions about the cosmos that could be empirically verified or disproved, and help his land of ideas become a mathematical reality? Of course it could, and Einstein was well aware of this even a few years before this date, when he was still in the midst of confusion as he worked on his theory: »It turns out«, he wrote in 1911, »that according to the theory I am going to set forth, rays of light passing near the sun experience a deflection by its gravitational field, so that a fixed star appearing near the sun displays an apparent increase of its angular distance from the latter, which amounts to almost one second of arc.«[4] The exact value, he said, was 0.83 arc seconds, and he concluded that »one of the most important consequences of that analysis is accessible to experimental test.« Einstein at this point in time was unaware that Johann Georg von Soldner had calculated exactly the same value in the Berliner Astronomisches Jahrbuch as far back as 1804, solely based on Newton's corpuscular theory of light. The measurement of the effect would not have provided any kind of ontological force for Einstein's theory. What's more, his calculation was not quite correct. In this case, ignorance paid off. Probably in the expectation that the Prussian Academy would bear part of the costs for an expedition to measure the deflection of light during a solar eclipse, Einstein moved permanently to Berlin in April 1914, taking up a professorship and becoming a

full member of the academy, thanks to the efforts of Max Planck. Conveniently, a total solar eclipse was due to occur shortly. It would cast its shadow right across southern Russia on 21 August 1914. Erwin Freundlich had agreed to lead the expedition some time before. After Gustav Krupp as the patron said he was prepared to cover the remaining costs of the expedition, the trip could finally go ahead. At the end of July 1914, a team headed off to the Crimea to watch for the deflection of starlight in the umbra of the eclipse for two minutes and fourteen seconds.
Of course, Freundlich and his two companions never even got a chance to point a single one of their telescopes at the darkened skies. On 1 August 1914 Germany declared war on Russia. Freundlich and his group were immediately arrested, imprisoned and their equipment confiscated. In any case, they would not have been able to try to see the deflection of light because the skies over the Crimea were overcast on the day of the solar eclipse. No doubt Einstein was relieved when Freundlich returned to Berlin just a few weeks later following an exchange of prisoners in which he was traded for Russian officers. He probably took a calm view in any case to this failed attempt – for the time being – to measure the deflection of light. Just a few months before the expedition, he had written to his close friend Michele Besso, saying he was »completely satisfied and no longer doubt the correctness of the whole system, regardless of whether the observation of the solar eclipse will succeed or not. The logic of the thing is too evident.«[5] Once more, everything was just a question of time.
A little more time was not exactly a bad thing given the actual value of the deflection of light in the general theory of relativity. Einstein only succeeded on that day in November 1915 in calculating the definitive value of 1.7 arc seconds for the deflection of a light ray passing the surface of the sun. He did this in the same report in which he dealt with the Mercury anomaly. His value was twice that calculated with Newtonian theory. But while war waged, there was no hope of another attempt to measure it.

Only after the end of the First World War did the opportunity present itself again to seriously consider an expedition to measure the deflection of light in strong gravitational fields. The next promising solar eclipse, which would take place before the exceptionally bright Hyades, was already casting its shadow – ready and waiting to mourn Newton's downfall. This time the path of darkness would move right across the Atlantic on 29 May 1919, and the British Royal Society was all set to carry out the mission. The key figures involved in the expedition were the highly respected Plumian Professor of Astronomy and Quaker Arthur Stanley Eddington and the Astronomer Royal Sir Frank Watson Dyson. Eddington in particular played a crucial role in making the general theory of relativity into that what it would become. Not only was he an exceptionally gifted mathematician and the first ever second year undergraduate student at Cambridge to pass the Mathematical Tripos with the best grade, earning the title of Senior Wrangler; he also, and much more importantly, had an exceptional coach to help him prepare for his exams. Each year his coach, Robert Alfred Herman, gave an introductory course on differential geometry, which was an exception found nowhere else. This meant that Eddington belonged to a hand-picked circle of the few mathematical physicists in the world who mastered the key principles of this field.[6] It is also the very subfield of mathematics on which Einstein's theory of gravity would be based. Einstein had spent years familiarising himself with differential geometry, with keen support from the mathematician Marcel Grossmann. Eddington probably knew fairly precisely what lay ahead of him and what an advantage his education gave him when, despite the embargo on direct exchanges between British and German science, he was informed by the Dutch astronomer Willem

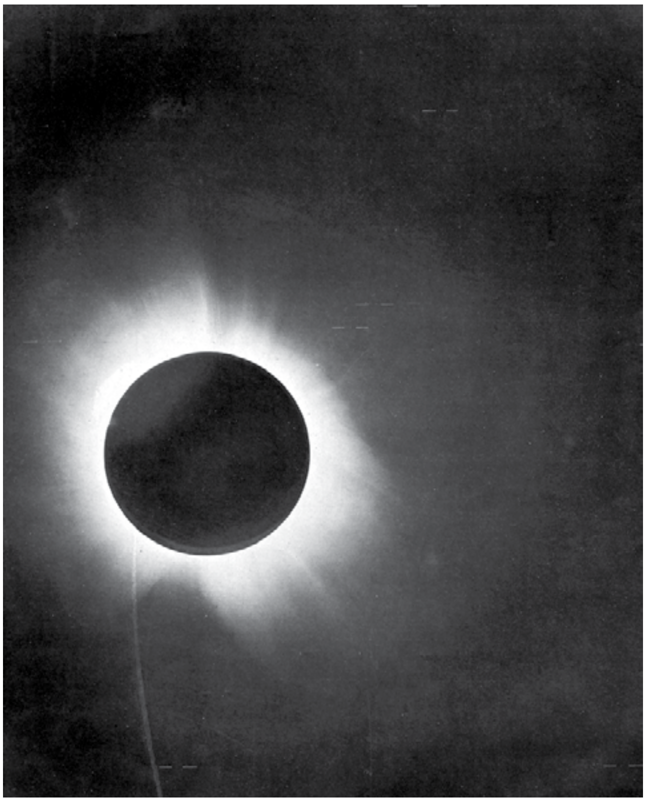


Image 2: Positive from one of the photographic plates taken in Sobral. The positions of stars are indicated by two horizontal lines at their centre. The difference between the positions of the stars on the comparison plates amounted to approximately 1/60 mm and hence less than a quarter of the apparent size of the stars.

de Sitter of Einstein's work. Eddington was enthralled right from the start, and he was one of the few members of the British scientific community to write on the general theory of relativity and played an important role in bringing it to wider attention.

In March 1919, two British expeditions put out to sea in order to take photographs of stars close to the sun during the six minutes and fifty-one seconds of the upcoming total solar eclipse.[7] These would then be compared with photographs of the same star field taken when the sun was positioned elsewhere in the skies. The difference between the apparent positions of the stars should correspond, quite simply, to the deflection of light in the gravitational field of the sun. At least in theory. In practice, the undertaking turned out to be much less simple. Were the photographs taken on the same scale? What was the orientation of the photographic plates to the optical axis? What optical errors and differences might arise due to the sudden change in temperature during the eclipse and the comparison photographs taken during actual night? In order to be able to estimate all these errors to some degree, half a dozen easily identifiable stars would have to be photographed multiple times at the same moment.

This task was entrusted to Eddington himself, who headed with Cottingham to Principe, an island in the Gulf of Guinea, and to Crommelin and Davidson, whose destination was Sobral on the Brazilian coast. The Sobral party was lucky with sunny weather on the day of the eclipse, and they took a large number of easily identifiable photographs with their two telescopes. Eddington and Cottingham on the other hand had just a single telescope and were plagued by a cloud field. They took their photos in the mist, hoping for good luck. Only a few of the photographs were usable. This meant there were three datasets of variable quality for the evaluation. In one respect, the result was clear: light rays are deflected in a gravitational field. Unfortunately, the value was not especially satisfactory and stood precisely between Einstein's prediction and, a little surprisingly, Newton's figure. However, if one set of photographic plates from Sobral was excluded because, although it was taken with the highest-quality of the three telescopes, an elevated systematic error was suspected,[8] the evidence was clearly on Einstein's side. On 6 November 1919, Eddington and Dyson presented this interpretation of their results in Burlington House to the general assembly of the Royal Society and the Royal Astronomical Society, and no less than Sir Joseph John Thomson, president of the Royal Society and chair of the assembly, announced that Einstein's value had been confirmed beyond doubt. The matter was settled.[9]

Overnight, it seemed, Albert Einstein had become a global scientific celebrity. The next day, the headline in *The Times* in London read: »*Revolution in Science. New Theory of the Universe. Newtonian Ideas Overthrown.*«[10] A report appeared in the *New York Times* on 10 November with the headline: »*Lights All Askew in the Heavens. Men of Science More or Less Agog Over Results of Eclipse Observations. Einstein Theory Triumphs. Stars Not Where They Seemed or Were Calculated to be, but Nobody Need Worry*. [...]«[11] With Einstein, the universe had taken on a new mathematical structure that presented an entirely new perspective on space, time and matter. Space-time was indeed curved and no longer had a distinguished system of reference. According to general relativity, astronomical objects only follow paths that are as straight as possible through curved space-time. Gravity lost its status as a force. It became a geometric effect that spreads at the speed of light and, in extreme cases, bends light and slows time. The last of these claims still remained to be demonstrated. But it was still a once-in-a-century sensation. It was clear what had to happen next: the Nobel Prize.

But this is precisely what Einstein did not get, at least not for his work on his general theory of relativity. Albert Einstein was by no means an unknown name to the Committee for Physics of the Royal Swedish Academy of Sciences. Repeatedly he had been put forward for the Nobel Prize for his work on relativity, before and during the war. And repeatedly the committee refused to grant him the prize, claiming that his theories first had to prove themselves and demonstrate they were a significant contribution to physics.[12] After the revolutionary confirmation of the deflection of light by gravitational fields during the 1919 solar eclipse, it was only natural that Einstein's name dominated the list of nominations for 1920. These nominations came from the most eminent figures in physics. But the committee followed the report before it, which recognised that Einstein's theory may have explained the anomaly of Mercury but questioned the positive result of the British expedition and denied there was any evidence for his theory. With that it was decided that Einstein and his theory were not contenders for the prize. Figures such as Philipp Lenard had agitated against Einstein, seeking to condemn the scientist, his all-too mathematical frippery and his Jewish theory because they called into question the noble German and Aryan physics of measuring, weighing and documenting. These nationalistic and anti-Semitic machinations had paid off. Despite this, Einstein received half of all the nominations in 1921. But once again the committee had before it a questionable report, discrediting the theory of relativity and claiming it was of no significance. Still not one of the committee members could warm to these mathematical speculations and support them: they were, after all, not based on any proper laboratory experiments, and it was not even certain that they really were physics. The academy took the only way out it could see and decided not to award a Nobel Prize in Physics in 1921. The following year, Einstein once again received a large number of nominations. Strangely, amongst them was a single nomination that put him forward for the prize for his work on the photoelectric effect in 1905. For the clique at the academy, this was the ideal way to give into international pressure without looking completely ridiculous but still maintaining its deep-set rejection of relativity. Einstein retrospectively received the Nobel Prize in Physics in 1921 »for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect.«[13] Einstein was prevented from attending the banquet in the Grand Hôtel in Stockholm in December 1922 as he was travelling in Japan. The award ceremony was postponed until 11 July of the following year and held in Gothenburg. On that day, almost two thousand people were waiting in anticipation to hear the lecture, which according to tradition, should be on the topic for which the prize had been awarded. Naturally, Einstein spoke on the »Fundamental Ideas and Problems of the Theory of Relativity«.[14] The general theory of relativity could no longer be stopped.

[1] Königlich-Preußische Akademie der Wissenschaft (Royal Prussian Academy of Sciences, Berlin), »Sitzungsberichte« (1915), 831–839; trans. by Brian Doyle, ed. by Kenneth R. Lang and Owen Gingerich, taken from »The Collected Papers of Albert Einstein« Volume 6, Writings 1914–1917, Document 24.

[2] Karl Schwarzschild to Albert Einstein, December 1915. In: »The Collected Papers of Albert Einstein« Volume 8, Part A: Letters 1914–1917, Document 169, trans. by Ann M. Hentschel.

[3] The Romulans fictional act is therefore not that far removed from the scientific model.

[4] Einstein, Albert: »Über den Einfluß der Schwerkraft auf die Ausbreitung des Lichtes.« Annalen der Physik 35 (1911), pp. 898–908, trans. by Anna Beck in »The Collected Papers of Albert Einstein« Volume 3, Writings 1909–1911, Document 23.

[5] Albert Einstein to Michele Besso, March 1914. In: »The Collected Papers of Albert Einstein« Volume 5: The Swiss Years: Correspondence, 1902–1914, Document 514, trans. by Anna Beck.

[6] Warwick, Andrew: »Masters of Theory.« The University of Chicago Press (2003). Chapter 9.

[7] Earman, John and Glymour, Clark: »Relativity and Eclipses: The British Eclipse Expeditions of 1919 and Their Predecessors.« Historical Studies in the Physical Sciences 11 (1980), 49–85.

[8] The coelostat in this telescope was astigmatic.

[9] This course of action was also justifiable, as later measurements would show.

[10] The Times, 7 November 1919.

[11] The New York Times, 10 November 1919.

[12] Friedman, Marc Robert: »The Politics of Excellence: Behind the Nobel Prize in Science.« New York: Freeman & Times Books, Henry Holt & Co. (2001). Chapter 7.

[13] »The Nobel Prize in Physics 1921«. Nobelprize.org. Nobel Media AB 2014.

[14] Einstein was in fact entitled to choose the subject of his lecture as it was not the official Nobel Prize award ceremony. The suggestion that he should speak on his theory of relativity was made by a member of the Nobel committee. See: Svante Arrhenius to Albert Einstein, March 1923. In: »The Collected Papers of Albert Einstein« Volume 13: The Berlin Years: Writing & Correspondence January 1922 – March 1923, Document 445.

To be continued in Newsletter#11

Stefan Zieme
Base project »Experimental Systems«

From the Experimental Zone #04

Experimental settings Recap

The signs above the workstations used by participants in the Experimental Zone provide information on the issues and themes they are currently working on, even if the participants themselves are elsewhere. (Photo: Fabian Scholz | Image Knowledge Gestaltung 2015)

Experimental setting »Navi« June 2015

The experimental setting »Navi« ran in September. »Navi« is a tool that provides Experimental Zone participants with a kind of »commentating navigation system« for the physical space of the Experimental Zone. In practice, it consists of A3 boards that can be hung from any point on the ceiling. They can be written on, either by hand or by attaching printouts.

The theoretical idea behind »Navi« is to form a closer, empirical understanding of the »activities of the space« through participants' perception of the space. As a tool for participants, »Navi« should reveal the developing semantic structures of the space based on its use. The hypothesis is that these structures arise from interactions between people, space and objects. »Navi« is intended to approximate this structure from the human side.

Participants were informed that places and points in the Experimental Zone could be marked and annotated using signs to indicate what was currently happening at that point. As an example, the following »questions to the space« were formulated: what is the space doing? What is the space like? What is being done in the space or with it? What activities are in progress, what activities cannot be performed? Which kinds of expertise are available and where? Where is expertise being sought? What spatial, technical and infrastructural possibilities and impossibilities are there and where are they located? What would I like to

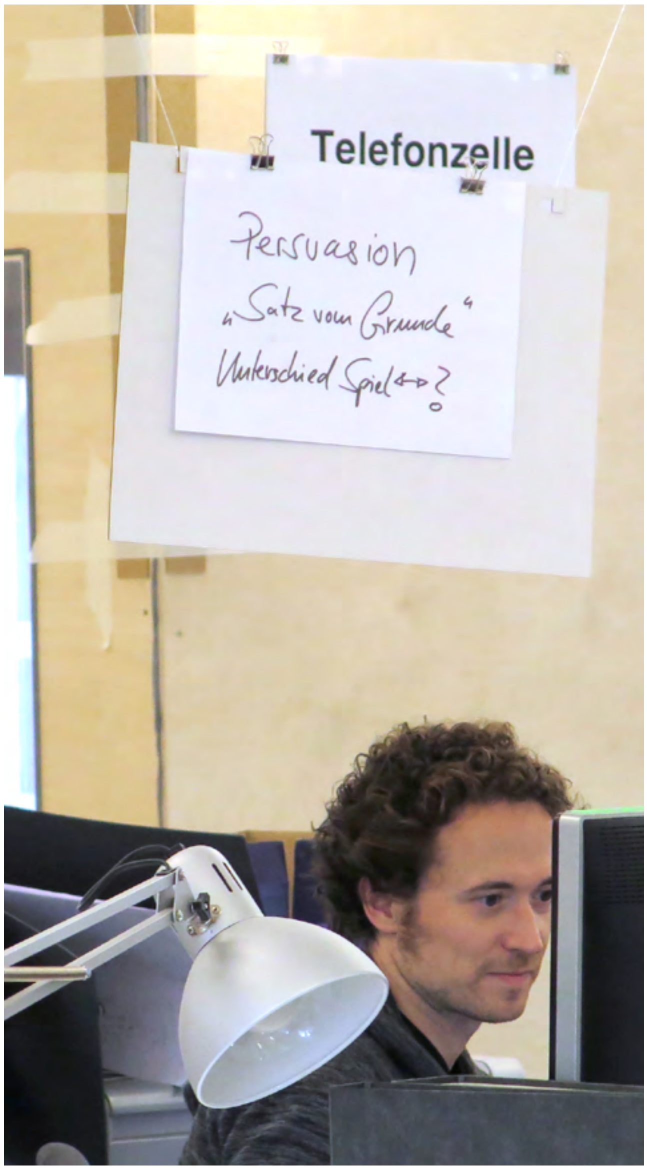
From the Experimental Zone #04

ask the space?

»Navi« was used to display the infrastructure located in particular points (especially tools, etc.) and to indicate the research work and issues currently in progress at specific locations. As such, it does not provide information on the activities of the space but only on the activities in the space. Based on this, the hypothesis could be put forward that an empirical tool such as »Navi« only enables space to be examined if it is used in a context in which the visual marking of (action) spaces is either already a common cultural practice or if such markings are easily integrated into the existing practices of using and interacting with space.

Stefan Solleder
Base project »Experiment & Observation«

Henrike Rabe
Base project »Architectures of Knowledge«



(Photo: Fabian Scholz | Image Knowledge Gestaltung 2015)

Experimental Zone report

(Photo: Friedrich Schmidgall | Image Knowledge Gestaltung 2015)

Workshop report: Experts in Experimentation 2

The Experimental Zone and its settings raise the question of how experiments are conceptualised, a question that was previously explored in the workshop »Experts in Experimentation 1« (see report in Newsletter 8). At the workshop, participants presented and discussed hypothesis-driven, exploratory and simulation-based experiments in biology and psychology, observational-descriptive experimental structures from biological morphology and architectural thought experiments, amongst others. The Experimental Zone's processual character was highlighted, and the discussion examined the extent to which the Experimental Zone is an experimental tool or the object of an experiment.

To continue this debate, the Experimental Zone team invited scientists and researchers from different disciplines to the workshop »Experts in Experimentation 2« on 12 November 2015: Robert Gaschler from psychology, Christian Kassung from cultural studies, John Nyakatura from biology, Jürgen P. Rabe from experimental physics, Hans-Jörg Rheinberger from the history of science, Regina Römhild from European ethnology, Wolfgang Schäffner from cultural studies and Matthias Staudacher from theoretical physics. After a brief presentation of the Experimental Zone, the workshop began with contributions from the invited experts, which provided stimulus for a lively discussion.

Regina Römhild began her talk by explaining that European ethnology is not explicitly experimental; instead, since Clifford Geertz it has seen itself first and foremost as an interpretative discipline. In the discipline's early days, »experimentation« in ethnology consisted of fieldwork, during which field researchers made themselves into an instrument. The objective was to understand the observed culture in its very essence and to then distance oneself from it in order to transform what had been learnt into objective knowledge. Here European ethnology in its early stages of development used terminology from the natural sciences in order to establish itself as a scientific discipline. As Römhild explained, the field researchers themselves are a fundamental problem as they »disrupt« the object of the enquiry, and the Experimental Zone faces a similar challenge. She noted that the falsification of results in ethnology is avoided by comparing many similar contexts and by clearly indicating work on case studies.

In the field of ethnomethodology by contrast, disruption is used intentionally as an experimental tool in order to gain an understanding of social norms. Römhild compared it to the popular example of the »hidden camera«: the norm only becomes evident when it is disrupted. She also noted that comparing apparently disparate phenomena is a way to scrutinise existing knowledge. Margaret Mead's research on adolescence and sexuality in Samoa, for example, was compared to the American/European model and played an important role in the western debate on sexual liberation. More recent experimental trends have abandoned the retrospective/analytical approach and turned to imaginative knowledge-production practices. This, Römhild noted, brings ethnology closer to cultural production and art, enabling it as an experimental practice to make the familiar alienating and the alien familiar.

The experimental physicist Jürgen Rabe began by explaining that the role of experimentation in physics can be immensely varied – but the goal is always the same: to reach a better understanding of nature. »Understanding« here means the ability to predict something in the future correctly. On the one hand, theoretical hypotheses are tested in experiments. On the other, exploratory experiments are also required as there may not always be existing verifiable hypotheses. Simulations form a third category of experiments because here aspects of theory and experiment flow into each other. Rabe went on to note that progress in physics is only possible through an interaction of theory and practice; it is the triad of theory-simulation-experimentation that makes physics. Rabe used an example to illustrate how experimentation shows the limits of theories: whilst theory ruled out the existence of stable, strictly two-dimensional crystals, individual molecular layers could be visualised in the experimental structure of a scanning tunnelling microscope – and shortly afterwards, they were produced in the form of free graphene layers. The scanning tunnelling microscope as an exploratory experimental structure and its exceptional ability to visualise real spaces overcame the ambiguities left by electron diffraction, thereby providing impetus for the evaluation of predictions about the future.

Christian Kassung provided three examples to illustrate the complex interrelationship between theory and practice. The experimental trick employed by Galileo in order to be able to describe empirically the free fall of bodies was to use a sloping surface – but merely by tilting the free fall away from the vertical onto a sloping surface meant it was impossible to proceed without a theoretical basis for the experiment: Galileo, said Kassung, had to invest a great deal of work in proving geometrically what Ernst Mach was later able to visualise almost directly through the medium of chronophotography. An example of a hypothesis-driven experiment that empirically verified a theoretical prediction is the discovery of Uranus. Based on earlier calculations of its position, the planet was discovered using a telescope, but Uranus alone could not be responsible for the theoretically calculated deviations in the orbits of the planets, and so research continued. As Kassung noted, the classic iterative loop of theory and empirical testing was put straight into action immediately after the experimental verification. The third example he presented was an essay by Matvei Bronstein from 1933. In this essay, Bronstein developed a model of physical theories in a three-dimensional cube, the »cube of physics«, but it was conceived first and foremost as theory-induced thought experiment. It remains until this day a hypothesis that is as productive as it is problematic.

Matthias Staudacher described the division of physics into theoretical and experimental physics as somewhat crude. In his view, physics in practice is a happy interaction of these two poles. He outlined how the clear-cut division between theory and experiment begins to disappear when faced with the question of whether a tabletop experiment has anything to do with CERN and, if so, what, and how space telescopes and satellites fit into this relationship. When a supercomputer calculates a spectrum, it raises the question of whether this is an experiment, a theory or something of a third kind, said Staudacher. Many of the key insights into physics do not stem from experiments but from purely theoretical reflections, he noted. Einstein, for instance, worked out in his head that something was not right with physics by, as he put it himself, imagining he was riding on a beam of light. Such thought experiments continue to advance physics today, said Staudacher, for example, in the case of attempts to understand and simplify theories with the help of mathematics or to bring theories into agreement with each other.

The discussion round then examined interdisciplinarity and architectures of knowledge from the perspective of knowledge spaces, looking at the renovation project IRIS (Integrative Research Institute for the Sciences) in Adlershof and the interdisciplinary project »Experimental Systems«. This project has shown that interdisciplinarity can only work if the researchers involved are working on a joint research question. The project needs concretisation, in this case in the form of the cube of physics mentioned above. Space in a physics laboratory has the task of negotiating deeper reflection and dialogue, and thereby fostering the interweaving of theory and experiment. The question was raised in the discussion of what influence a change in the configuration of furniture may have and from which point in time and how this influence could be measured. Here the discussion emphasised that any examination of experimentation must also consider the concept of experimental systems.

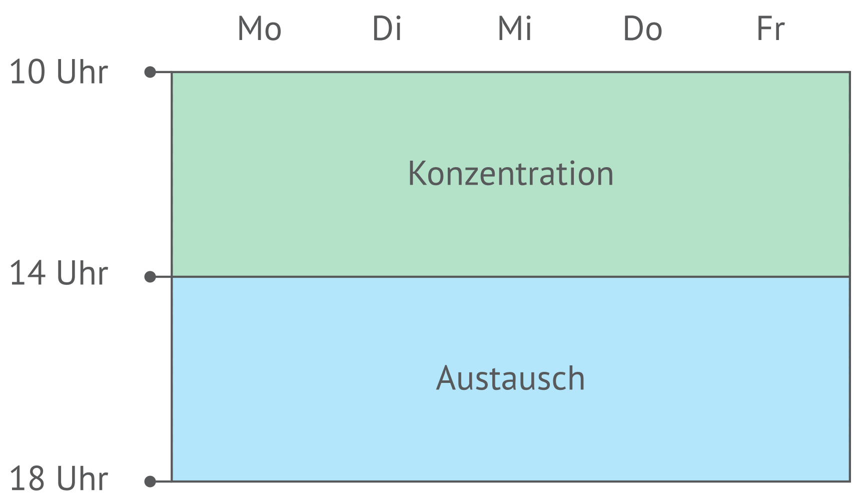
The field of enquiry in which the questions explored in the Experimental Zone are situated is this: how are space and interdisciplinary research connected, and how can this interrelationship be experimentalised? During the discussion, it was suggested that questions within this area of research needed to be defined more precisely – which is very much in line with the concept of the Experimental Zone as a tool at the researchers' disposal that can be calibrated to specific situations they want to investigate. Here the question arises of how this calibration can be targeted to examine interdisciplinarity in research.
Situated between participatory observation and the targeted manipulation of the settings, the Experimental Zone stands at the crossroads between experimentation and fieldwork. It exploratory character provides an opportunity to identify the correlations in previously collected data, correlations which may be used to define more precisely the questions of space and interdisciplinarity. It is conceivable that the Experimental Zone could provide an opportunity, amongst other things, to identify parallels and differences between different disciplines through the possibilities it offers for observing and measuring interaction, productivity and different practices. As Wolfgang Schäffner remarked in the discussion, the question of interdisciplinarity is fundamentally a question of differences and unfamiliarities –, which in practice may be larger within one's own discipline than between seemingly disparate disciplines, as Jürgen Rabe noted towards the end of the workshop. He gave as an example the dissolving boundaries between chemistry and physics on the one hand and the sometimes very clear differences within physics.

This article has only briefly summarised the discussion, but it shows how findings from the first workshop were expanded and explored in greater depth, and how it has helped define the concept of experimentation in the Experimental Zone with greater clarity. We would like to extend our warm thanks to all the experts in experimentation for their contributions. We as the Experimental Zone team had already been planning to focus our research questions more clearly, and we have taken away many specific points of reference from the discussion.

Fabian Scholz
Base project »Architectures of Knowledge«

The Experimental Zone from February

The aim of the Experimental Zone is to iteratively design, observe and analyse the spaces used in interdisciplinary collaboration. The experimental settings are intended to address a specific research question or to collect data that is not gathered through continual observation.



The Experimental Zone online

▶ **The Experimental Zone podcast**
on bwg.hu-berlin.de

▶ **Online documentation**
on intern.bwg.hu-berlin.de

▶ **The Experimental Zone group**
on intern.bwg.hu-berlin.de

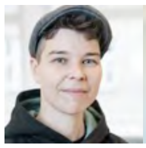
Experimental setting 08 »Exchange: temporal«

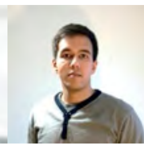
Overarching themes have been explored in the previous experimental settings. Settings such as »Activity wall«, »Themes of work… and »Diary« examined the question of how themes and work practices can be visualised, whilst the central focus of settings such as »Basic setting«, »Newspaper …« and »Practices« was the issue of the influence of physical space typologies.

The key theme for the next three settings will be »Exchange«. Exchanges, whether they are formal or informal »exchanges of ideas«, play a vital role in interdisciplinary research processes. Yet exchanges and discussions cannot replace concentrated individual work.

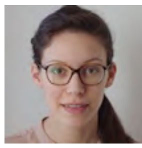
How can space enable both exchanges and concentrated individual work? To investigate this question, settings 08, 09 and 10 will test three different scenarios: »Temporal«, »Screened« and »Hermetic«.

In the first of the three settings, »Exchange: Temporal« (February and March), there will be no acoustic or visual divisions between spaces for exchanges and those for concentration. Instead, we will attempt a time-based division: the first half of the day will be for concentrated individual work, while we want the second half to be an opportunity for exchanges.

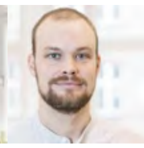

Julia Blumenthal


Sammy David


Henrike Rabe


Séverine Marguin


Friedrich Schmidgall


Fabian Scholz

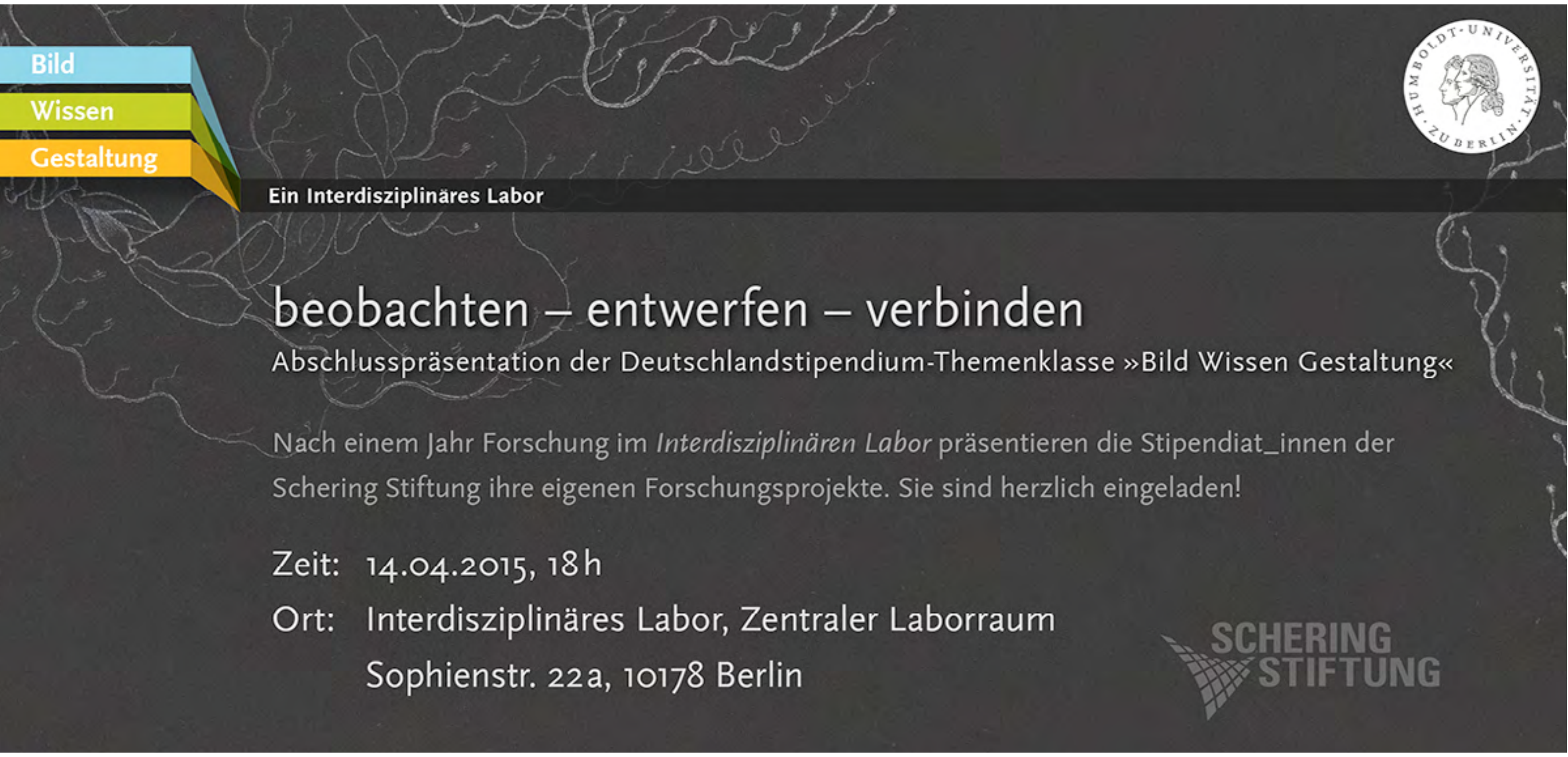

Christian Stein


Benjamin Thomack

For further information or if you are interested in having a workspace in the Experimental Zone, please contact:
bwg.experimentalzone@hu-berlin.de

A Look Ahead

Final presentation by the *theme class Image Knowledge Gestaltung* 14/04

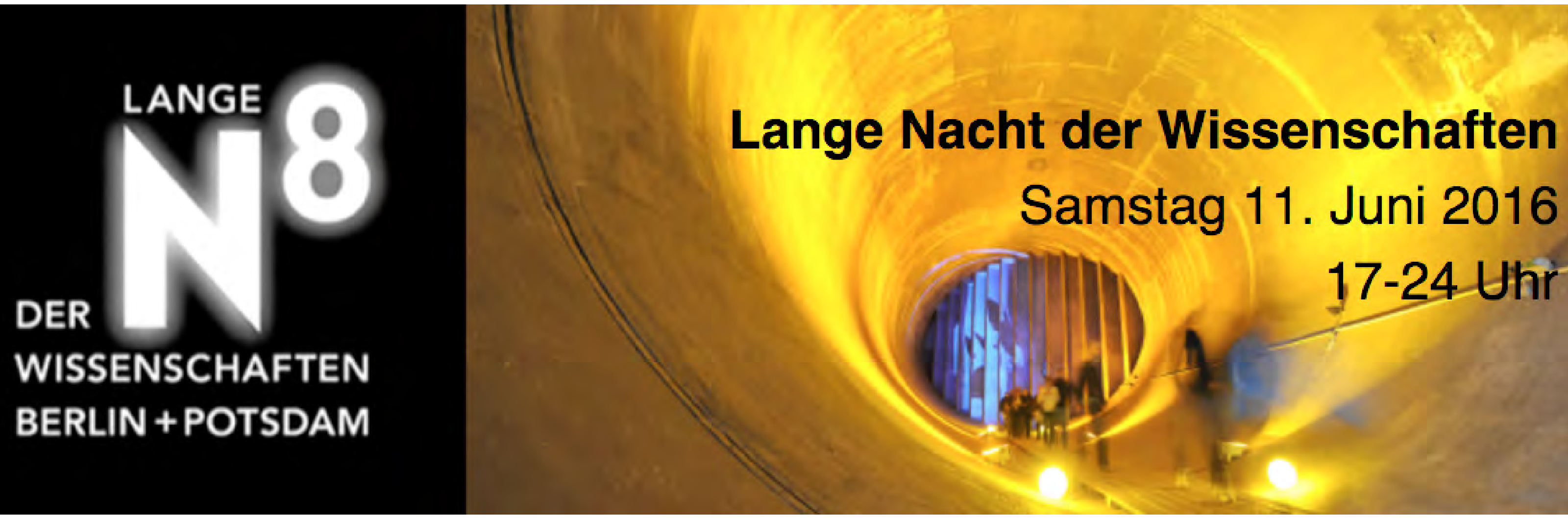


The Germany Scholarship holders in the theme class »Image Knowledge Gestaltung« will present the results of their research work on 14 April 2016 at 6 pm in the Cluster's *Central Laboratory*.

Katrina Schulz
SHK Nachwuchsförderung

Franziska Wegener
Nachwuchsförderung

Long Night of the Sciences 11/06



The time has come again! On 11 June, more than seventy institutions in Berlin and Potsdam will open their doors for the 16th Long Night of the Sciences, and the Interdisciplinary Laboratory Image Knowledge Gestaltung does not want to miss this chance to give visitors the low-down on current projects and will have lots in store to entice and enthral the public – including a gender roulette for all ages, where there's plenty of fun to be had tracking down this »gender«. Visitors will also have a chance to hear about the publication »beobachten – entwerfen – verbinden«, produced by the scholarship holders in the Image Knowledge Gestaltung theme class to present the results of their project work in the Interdisciplinary Laboratory over the last year. The new comic on the Anthropocene kitchen will also be presented to the public – accompanied with informative background material and details on how the comic was produced, plus a chance to taste some culinary delights – with the legendary »bee sting cake«. As always, the bar will be serving white and red wine and sparkling fruit juice for you to enjoy during the long night.

Date: Saturday, 11 June 2016, 5–12 pm
Location: Hall of the Helmholtz Centre for Cultural Techniques in the main building of the Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin

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Cover photo: The base project »Mobile Structures« has activated the second prototype for a kinetic spatial installation in the Martin-Gropius-Bau as part of the exhibition »+ultra.knowledge creates gestaltung«. The image shows the electromechanical system.

Text: Sabine Hansmann
Photo: Benjamin Meurer | Image Knowledge Gestaltung 2016

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